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MINERAL RESOURCES

OF

ADAMS COUNTY

PENNSYLVANIA

BY
GEORGE W. STOSE

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TOPOGRAPHIC AND GEOLOGIC SURVEY
BULLETIN C-1
1925

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U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

PENNSYLVANIA GEOLOGICAL SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST
COUNTY REPORTS, ADAMS COUNTY PLATE 1

MAP OF ADAMS COUNTY, PENNSYLVANIA SHOWING MINERAL PRODUCTS

Geology By
George W. Stose
of the United States Geological Survey

Scale

EXPLANATION

Triassic Gabbro of Iron Hill
(possible for crushed stone, foundations, and building stone; formerly used for road metal; not now quarried)

Triassic red shale and sandstone
(some of the sandstone is suitable for foundations and building stone; shale is suitable for brick and terra cotta; formerly used for road material; red shale and some sandstone are soft, and are recommended for prospecting by pits for roads or surface deposits)

Pleistocene limestone
(limestone for road material, lime, and lime burning; marl used for marl; limestone strata in thick-gravel limestone terrace; limestone for road material; red marl and gravel formerly used for road material; limestone, and fragments, brick are present in places at extent of quarries and Pleistocene limestone)

Cambrian quartzite, conglomerate and shale
(some quartzose pebbles for foundations, building stone, road material, ballast, and fragments; brick are present in places at extent of quarries and Pleistocene limestone)

Pre-Cambrian crystalline rocks
(some is suitable for road material; some pebbles report, small quantities used of which is crushed and prepared for road material; some is suitable for road material and some pebbles; gneiss and schist, and mica schist, used extensively for road material; the gneiss schists are poorly, the gneiss schists for paper and brick clay, the quartz for ground silicon and limited stone (mostly granodioritic stone))

Y. Quartzite, rock stone, processing stone

Y. Prospect site and abandoned quartzite rock stone

Gettysburg

Cashtown Park

Mt. Tom

Mt. Pleasant

Mt. Hope

Mt. Misery

Mt. Sherman

Mt. Joy

Mt. Carmel

Mt. Pisgah

Mt. Olivet

Mt. Zion

Mt. Vernon

Mt. Olivet

Mt. Zion

Mt. Vernon

Mt. Olivet

Mt. Zion

Mt. Vernon

PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

BULLETIN C 1
PART II

MINERAL RESOURCES

OF

ADAMS COUNTY
PENNSYLVANIA

By

GEORGE W. STOSE

of the U. S. Geological Survey

Done in cooperation with the United States Geological Survey

Department of Forests and Waters
R. Y. Stuart, Secretary

Topographic and Geologic Survey
G. H. Ashley, State Geologist

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Mineral Resources of Adams
County Pennsylvania

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By R. Y. STUART
Secretary, Department of Forests and Waters
for the
Commonwealth of Pennsylvania

LETTER OF TRANSMITTAL

R. Y. Stuart, Secretary,

Department of Forests and Waters.

Sir:

It is my hope that the Topographic and Geologic Survey may prepare a report on the geology, mineral resources, and soils of each county in Pennsylvania. These reports should be of material benefit in the development of the natural resources of the respective counties and of wide and varied use. When I came to Harrisburg as State Geologist in 1919 I found that Mr. R. R. Hice, my predecessor, had arranged with the United States Geological Survey for the publication by the Topographic and Geologic Survey Commission of a report on the mineral resources of the Fairfield and Gettysburg quadrangles. This report was written by George W. Stose, a geologist of the U. S. Geological Survey. As the two quadrangles cover nearly all of Adams County, I arranged for additional field work to be done by Mr. Stose in order that the report might cover the whole county, and serve as the chapter on mineral resources for the first of the series of county reports.

In the accompanying manuscript Mr. Stose describes not only the present mineral industry of the county but also calls attention to resources yet to be developed. If the publication of this report leads to the quarrying of ornamental stone, polished specimens of which are shown in several colored plates, the cost will have been more than justified. Deposits of high grade clay are not being utilized, and Mr. Stose indicates where drilling may well be expected to disclose commercial bodies of magnetite.

Acknowledgment is made of the generosity shown by the U. S. Geological Survey in cooperating with such a true scientific spirit in permitting the publication of the information contained in this report, most of which is the work of that Survey.

This paper forms Part II of the Adams County report; Part I, not yet written, will describe the topography and geology.

A reconnaissance soil survey of Adams County by Austin L. Patrick, Department of Agronomy, Pennsylvania State College, and Hugh H. Bennet, Bureau of Soils, U. S. Department of Agriculture, will be offered for publication as a separate report. This soil survey was a triangular project participated in equally by the U. S. Bureau

of Soils, Pennsylvania State College, and the Pennsylvania Topographic and Geologic Survey. It will form Part III of the Adams County report. The three parts will be bound together for the Library edition of the report.

R. W. Stone of this Survey edited this report and also contributed to it some data, particularly regarding recent quarry operations.

I desire to acknowledge the cooperation of their respective Departments for photographs of polished specimens made by Mrs. Grace Rinehart, Department of Labor and Industry, and by Boyd Rothrock, curator of the State Museum, Department of Public Instruction.

Respectfully,

Geo. H. Ashley

State Geologist.

May, 1924.

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MINERAL RESOURCES OF ADAMS COUNTY, PA.[1]

By George W. Stose.

GENERAL DESCRIPTION.

The data here presented were in large part collected during a study of the area in 1907 to 1909 for the preparation of the Fairfield-Gettysburg geologic folio, to be published by the U. S. Geological Survey, supplemented by information obtained by examination of active properties in 1923 and 1924. The larger part of the county is a rolling lowland but it embraces also a strip of South Mountain on the west and a small part of the Pigeon Hills on the east and other lower hills on the southeast. (See Pl. II.) The lowland has a general altitude between 500 and 600 feet above sea level, above which South Mountain rises abruptly to an altitude of 1800 to 2200 feet. The rocks of South Mountain and of Pigeon Hills are hard, resistant Cambrian quartzites, conglomerates, and slates and older pre-Cambrian hardened metamorphosed volcanic rocks. The lowland southeast of South Mountain on which Gettysburg is situated is composed largely of soft red shales and sandstones of Triassic age in which are large masses and sheets of tough diabase and smaller sheets and dikes of the same rock which were intruded as molten lava into the bedded rocks. Paleozoic limestone underlies the Triassic sandy beds and is exposed at the surface near the western margin of the lowland in the vicinity of Fairfield and York Springs and at its eastern margin around McSherrystown, where the Triassic red beds have been eroded. The general distribution of these groups of rocks is shown in Plate I.

The pre-Cambrian lavas are the oldest rocks in the region. They consist of two kinds, an acidic lava, rhyolite, and a basic lava, basalt, which were once bedded lavas, in part obsidian with numerous open vesicles and pores, spherulites, and other structures that commonly occur in lavas. Pressure and heat in the presence of water in the depth of the earth beneath a load of thick sediment have changed the texture of the lavas to dense semicrystalline rocks which retain few of the original structures. The floor on which the lavas were poured out is not exposed in the county, but it is probably composed of

[1]Published by permission of the Director, U. S. Geological Survey in cooperation with the Topographic and Geologic Survey of Pennsylvania.

Plate II

A. South Mountain. Looking down Marsh Creek from its head where the Chambersburg-Gettysburg pike crosses the divide.

B. Lowland and foothills at east foot of South Mountain seen from Arendtsville.

crystalline granite, gneiss, and mica schist, as it is in other parts of southeastern Pennsylvania. The rhyolite was apparently the first lava to be extruded and later the basalt was erupted. Thin dikes and sheets of basalt also cut the rhyolite.

In early Paleozoic time the region was submerged beneath the sea, and sand, pebbles, and mud were washed into it from the surrounding hills, forming thick layers of sediments which have since been hardened into quartzite, slate or schist, and layers of rounded quartz pebbles or conglomerate. When the streams ceased to bring sand and clay into the sea, lime mud was deposited and this was later hardened into limestone and dolomite, thick beds of which overlie the sandy beds. The area was later uplifted, became land, and much of the sedimentary rock was removed by erosion. In Triassic time a deep basin between steep hills or mountain ranges was formed, into which red sand and clay mud were washed which later were hardened to bedded sandstone and red shale. Lava eruptions once more broke forth in the region, but if any reached the surface in the county it has been eroded as none now occurs there. Only the roots and offshoots of the lavas are now found as sheets, dikes, and masses within the bedded rocks. These once molten rocks on cooling hardened to diabase, one of the hardest and toughest rocks in the area.

A great variety of mineral deposits occurs in Adams County. Many of these deposits are now worked commercially or have been recently, and still others may be of commercial value in the future. Crushed stone has been extensively quarried for road material and building stone has been quarried to a less extent. Limestone has been quarried around Hanover, McSherrystown, Fairfield, and York Springs for many years, some of it being burned for lime and some being crushed for road material and concrete. Vein quartz was crushed for silica used in tile and pottery manufacture. Greenstone is crushed or granulated for roofing material, flooring, and artificial slate. Iron ore was formerly mined and smelted and it is quite possible that commercial deposits of high grade magnetite may also be discovered. Copper, although extensively prospected, has been mined only on a small scale and that not profitably. These workable deposits, as well as occurrences of many other mineral products which are at present of little or no commercial value but which some day may be valuable, are herein described.

NONMETALLIC PRODUCTS.

BUILDING STONE.

Several kinds of rock in the area are or have been used for building stone. Some have been used chiefly as dressed stone in the superstructure, others as rubble in foundations, walls, bridge piers, and stone arches, whereas some are specially suited for steps, sills, lintels, culvert stones, curb stones, and flagstones. Inasmuch as one kind of rock may be quarried for more than one of these purposes and some quarries have turned out several of these products, all such rocks will be described under the heading "building stone." Crushed stone, however, will be described under a separate heading. In the last 20 years concrete has increasingly replaced stone for building purposes, and the scarcity of labor and consequent high cost thereof have caused a further reduction in the quantity of stone quarried for this purpose. On this account, many of the quarries that formerly produced building stone and are described under this heading in this report are now producing only crushed stone or have ceased to operate.

Diabase or Gettysburg "granite."

Diabase, a coarse granular crystalline rock intrusive in the Triassic sedimentary rocks, has been quarried in the vicinity of Gettysburg for building stone. It is locally known in the trade as "Gettysburg granite." Because of its generally dark color it is somewhat somber for building stone but makes a very substantial structure. It is extensively used in Gettysburg as dressed stone in retaining walls, culverts, gutter and curb stones, steps, and monuments, and as rubble in foundations, and several buildings have been constructed of it.

Diabase is a rock resembling granite in that it is a compact, granular crystalline rock, but is darker than granite because it contains less of the light-colored mineral quartz and more of the dark-colored ferromagnesian minerals—augite, magnetite, and sometimes olivine. The feldspars also are largely plagioclase instead of the lighter-colored orthoclase. Because of the intricate intergrowth of the crystals of these component minerals the rock is tougher than most granites and harder to dress and work, and a well defined grain and rift are generally lacking or imperfect, but in the vicinity of Gettysburg these structures are fairly well developed so that dimension blocks having smooth surface and of uniform size can generally be quarried. Diabase resists weathering about as well as granite, and is not as badly affected by fire. It is dense, so that it can be given a high polish and can be used for decorative purposes. Dia-

base has not been quarried for building stone on a large scale in the county. The product of the 10 or more quaries to be described was largely used in Gettysburg and vicinity.

The chief body of diabase in Adams County is the large sheet or sill which outcrops in a belt a mile or two wide that crosses the county diagonally northeastward just southeast of Gettysburg. Its rocky ledges south of Gettysburg are shown in Plate III. In most of the quarries in this belt the rock is noticeably broken by widely spaced nearly vertical joints having two or more directions. In addition it has a pronounced horizontal rift, which tends to break the rock into horizontal sheets, and a vertical grain in two directions nearly at right angles to each other. The method used in working the best of the quarries is to expose a large face of the rock along a vertical northeast-southwest joint plane, which is also the direction of easiest vertical splitting or principal grain. A large block, about 10 feet thick, to insure vertical splitting, is then split along the principal grain for a length of 20 feet or more. A block 10 or more feet high is then loosened by wedges along the horizontal rift, and this is finally split into smaller lengths along the vertical southeast-northwest grain. In breaking up a mass into smaller blocks, it is split in the middle to insure a straight even break along the grain. By this means regular blocks 13 inches wide, 7 inches thick, and 13 feet long are broken out for use as steps. These require only a little tooling to give the surfaces proper smoothness. Blocks of other dimensions suitable for culverts, curbstones, walks, etc., can similarly be obtained.

The quarries of high-grade building stone were active several years ago, but are now idle. All are located along the west slope of the diabase hill which extends from Rocky Grove school 2 miles east of Gettysburg to the Baltimore pike, 2½ miles southeast of Gettysburg. They lie almost in a straight line which trends southwest, parallel to the sides of the diabase mass and about at its middle. The high-grade rock is apparently limited to this medial zone in which the rock breaks more regularly, due to the fact that the diabase sill when it was intruded into the Triassic sediments, cooled simultaneously from both the top and bottom. The strains developed in the middle of the cooling mass, which cooled slowly, were equal in all directions and the rock solidified as a homogeneous even-grained mass, which would split in one direction as readily as another. The principal vertical grain in a northeast-southwest direction parallel to the sides of the sill, which the rock now possesses, was probably produced by later compression of the solidified rock normal to this direction. The fact that the quarries are about one-half mile apart along this medial zone is probably accidental, determined largely by accessibility, and the intervening rock along this zone is believed to

Plate III

A. Diabase ledges. "Devil's Den" in the Gettysburg Battlefield Reservation.

B. Spheroidal weathering of diabase. The rock is weathering in place, the rest of the mass having fallen to grains. Three miles northeast of Hampton near Bakers School.

be equally good. The diabase quarries, the location of which is shown in Plate I, will next be described beginning at the north.

One of the largest quarries is at Granite Hill, 4 miles northeast of Gettysburg. It was opened by the Gettysburg Granite Co. which built capacious buildings at the railroad depot for storage, work shop, offices, and commissary, and evidently had prepared to put large quantities of Gettysburg "granite" on the eastern market. A railroad spur winds its way spirally around the hill from the main line to the quarry 60 feet above, on the south side of the hill. Two smaller openings are lower down on the north side of the hill and a large old quarry hole in the lowland north of the railroad track is full of water. The main quarry face is about 40 feet high and 50 to 60 feet long. Huge blocks which had been broken loose are somewhat irregular in shape, suggesting that the grain is not as even and regular as is desirable for the most economical working of the stone for building purposes. The horizontal sheets are 10 to 15 feet thick. The rock is fine even grain and dark gray. This quarry is said to have furnished stone for a bridge across Potomac River at Harpers Ferry. Prior to 1913 the quarry had been idle for several years, and the office buildings, railroad, and equipment, though still intact, showed signs of depreciation from disuse. From 1913 to 1918 it was operated by B. F. Pope for crushed stone, and in 1919 by M. Bennett & Sons of Indiana, Pa. In 1924 P. W. Stallsmith of Gettysburg was quarrying rock here for a residence close by on the Lincoln Highway. This newer quarry face is 200 feet long and about 10 feet high.

L. O. Beitler's quarry at Rocky Grove school, 2 miles east of Gettysburg, was one of the best building-stone quarries in the area. It had a quarry face 20 feet wide and 10 feet high. The rift and grain are well developed and the rock splits with an even fracture. The stone is a fine-grained, evenly speckled gray rock of pleasing appearance, and was used for building, for steps, and for monuments. The Beitler quarry has apparently been idle since 1917.

One mile southwest, just south of the Hanover road, several small quarries from which culvert stones and steps were obtained lie along the west side of the diabase ridge. Some of the surfaces of the split stone from these quarries are stained with rust from surficial waters that follow the joints and horizontal sheeting, which gives the product a distinctive quality as a building stone. Half a mile farther southwest, on the west side of Wolf Hill, is the Zeigler quarry, operated up to 1915 by C. W. Zeigler & Co. Some of the product of this quarry was dressed and polished in Gettysburg for cemetery monuments.

J. W. Flaharty's quarry, 1½ miles southeast of Gettysburg and southwest of Wolf Hill, had one of the largest quarry faces in the region, 15 feet high and 15 to 20 feet long. Blocks 6 feet by 4

feet by about 8 inches thick were mostly quarried for use in massive walls of large buildings. The rock is dark gray and some of it is very coarse grained. The quarry has apparently not been operated since 1908.

Near the Baltimore pike $1\frac{3}{4}$ miles south of Gettysburg is the quarry of the McAllister Co. The rock is of the usual character, gray and compact, and splits readily along the grain so that building blocks 6 inches to a foot thick, 1 to 2 feet wide, and of various lengths are commonly quarried. This quarry was deeper than any of the others, and like them has been idle many years.

Bushman's quarry, on the south side of Culps Hill, 1 mile southeast of Gettysburg, was originally worked for building stone and later furnished crushed stone for the government roads of the Gettysburg reservation. B. F. Lightner's quarry, on the northeast side of Powers Hill, 2 miles south of Gettysburg, was formerly an active building stone quarry and furnished the large dressed stones used in the wall around the National Cemetery in the Gettysburg Military Park. Another nearby quarry operated by Nathaniel Lightner was active until about 1905.

In the United States quarry on the southwest side of Powers Hill the horizontal sheeting is more highly developed, causing the rock to break into thinner layers than in most places, so that the rock splits into horizontal slabs of suitable thickness for gutter and curb stones, for which it was largely used. Probably the thin sheeting is surficial and the layers will be thicker with depth. This quarry has not been in operation in several years.

The Miller quarry half a mile north of Round Top station on the electric railroad was operated in 1923 and 1924 by Emory Rosensteel, and produced dressed stone for steps, lintels, culverts, and building stone. This was one of the two quarries operated in 1924, and its production of stone was small.

The Biggs quarry, a large quarry in the lowland south of Cemetery Hill, 1 mile south of Gettysburg, which produced only crushed rock for road material, is described under the heading "crushed stone."

Triassic sandstone.

Some of the thicker beds of Triassic sandstone are locally quarried for building stone. Many of the old historic houses in and around Gettysburg and old hostelries and homes along the Pittsburgh-Baltimore turnpike and other historic highways in the county were built of this red or brown rock. Some of the old arch bridges are also built of it. (See Plate IV.)

The color of the rock is a rich dark reddish brown, pleasing as a building stone and especially attractive for lintels, door steps, and trimmings to brick and stone houses. Much of the rock, however, scales badly after years of exposure, especially on the exposed bed-

Plate IV.

A. Quaker church near York Springs, Pa., built of Triassic red sandstone about 1790.

B. Stone arch bridge over Conewago Creek near Center Mills, Pa., built of Triassic red sandstone about 1840.

ding surfaces. Moisture, which enters certain bedding planes, probably more porous layers, freezes in cold weather and expands, causing thin sheets to scale from the bedding surface. Some layers crumble to grains under the same weathering process. This weathering seems to affect the sawed stone more noticeably than the rough dressed, and buildings made of the smoothly finished dressed rock in time become rough surfaced and scarred by scaling, so that the stone has become less popular for building purposes in recent years.

The red or brown building stone occurs chiefly in the western part of the Triassic sandstone area, west of the Gettysburg diabase sill. Large firm blocks for dam construction were quarried 1 mile west of Gettysburg, and foundation stone for dwellings is obtained at several small quarries near Gettysburg and New Oxford, but quarrying on a large scale has not been attempted in the county, as layers of proper thickness, sufficient firmness, and good color for building stone do not occur in large quantity. Many of the beds of lighter colored Triassic sandstone, which occurs chiefly east of the Gettysburg diabase sill, are somewhat firmer than the brown sandstone and have been locally used in dwellings, barns, and foundations. Hard red and green argillite, or hardened, baked shale, has been quarried for foundation stone 2 miles northwest of Gettysburg. It commonly occurs as a zone of variable thickness along the contact of Triassic shales and large intrusive masses of diabase. It generally breaks into such small masses in quarrying that it is better suited for crushed stone.

One mile northwest of York Springs, hard beds of Triassic conglomerate are quarried on the Dietrich property for foundation stones and walls in York Springs. The rock contains rounded pebbles of white quartz and quartzite up to 3 inches in size. The rock weathers porous and pitted, and therefore has a rough appearance.

Cambrian quartzite.

Cambrian quartzite occurs chiefly in South Mountain, in the western part of the county, but it also occurs in the Pigeon Hills at its eastern edge. Most of the quartzite is so massive and thick bedded that it yields irregular-shaped masses when quarried, but the beds adjacent to the limestone of the lowland occur in thin, even layers, suitable for building stone. These thinner beds have been quarried north of Caledonia Park, just west of the Adams County line, and this quartzite has been used to build houses in the villages along the Chambersburg-Gettysburg pike and on adjacent farms. It is slightly stained by iron oxide which gives it a pleasing yellow or brown color. Irregular quartzite blocks obtained by quarrying the more massive beds are used in walls, fences, and in dwellings along the pike in the western part of the county. This rock is popular in

the construction of summer homes recently built in South Mountain. It was used in the construction of the Caledonia iron furnace and other furnaces in the South Mountain and is extensively used to line lime kilns, for which purposes it is especially adapted because of its refractory or heat-resisting character.

Schistose rocks of South Mountain.

The schistose rocks of South Mountain have been quarried on a small scale for rough flagstones, which are used for culverts, rural walks, and similar purposes. The lower schistose Cambrian quartzite in most places breaks readily along shear planes into great slabs, and rough flagstones of large size are obtainable from this formation on the east slope of Piney Mountain, the west side of Mountain Creek valley, and elsewhere in the area of Cambrian quartzite in South Mountain indicated on the map, Plate I. On the east side of Buchanan Valley, a narrow band of this rock has been locally quarried for flagstones.

Some of the hard pre-Cambrian rhyolite porphyry has a marked schistose structure and on weathering breaks into large irregular slabs having rough sheared surfaces. This rock is harder and more enduring as flagstones than the schistose quartzite, but it is more difficult to work into usable stone. This porphyry composes most of the high ridges of the central part of the pre-Cambrian area, chiefly Big Hill, Bear Mountain, Snaggy Ridge, and Mount Newman. Slabs hauled from the mountains and roughly dressed are extensively used for walks and other purposes on the farms and in the smaller towns and villages. It is also quarried at Bridgeport, $1\frac{1}{4}$ miles northwest of Arendtsville. (See Pl. XI, p. 44.) The quarried rock is so irregular in size and thickness that it is difficult to dress it properly so that it will lie smoothly and evenly, and consequently it does not make so satisfactory a sidewalk as concrete, and the latter is gradually supplanting it, even in the smaller towns.

ORNAMENTAL STONE.

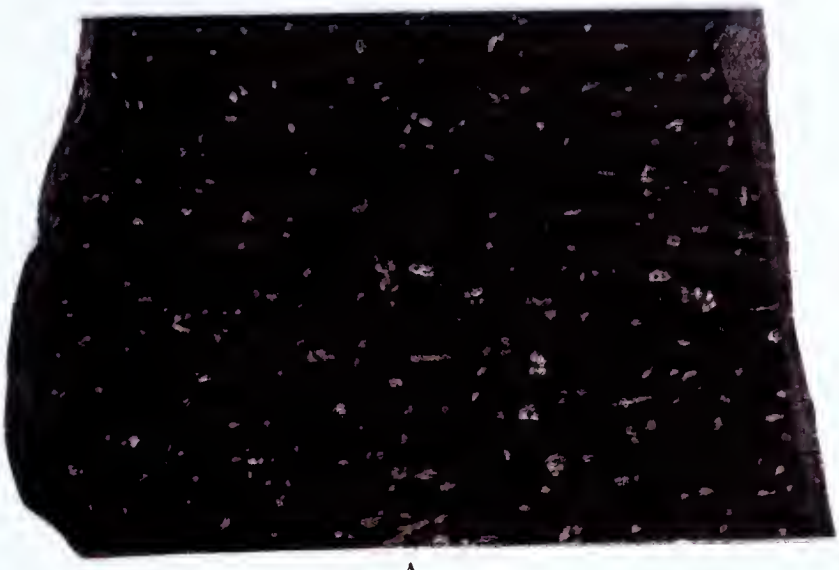
The rocks here referred to as of possible value as ornamental stone are so described because of their attractive coloring, denseness, and fineness of grain which permit a high polish. Up to the present time they have been quarried for other purposes on a small scale and by the use of blasting powder, so that the possibility of their commercial development for ornamental stone is not assured. It must first be determined whether any of the kinds of high grade rock of suitable color and markings can be obtained in large enough masses to be sawed into slabs for mantels, table tops, or monuments. Such products will also have to compete with ornamental stone already on the market. Even if large masses can not be obtained,

some of the rock here described,—especially greenstone finely speckled with green epidote and red jasper or blotched with burnt orange spots composed of a mixture of red oxide of copper and green epidote, and altered amygdaloidal rhyolite of pleasing color and pattern from the National Copper Company prospect at the old Bingham mine (Pls. V and VII)—may prove of value in the manufacture of arts-and-crafts jewelry, in which industry small fragments of attractive color and design can be cut and polished for use in cuff links, watch fobs, stick pins, brooches, lavallieres, necklaces, and similar articles. This branch of industry, however, is very limited and quarrying the rock solely for this use might not be warranted.

Among the great variety of rocks in the pre-Cambrian altered rhyolite and basalt lavas, technically known as metarhyolite and metabasalt, of South Mountain, some have colors and textures that make them desirable ornamental stones. Some of the metarhyolite is dense and fine grained so that it will take a good polish and it is not too hard to be economically quarried or worked. The more common variety is a dense squeezed rhyolite of dull-gray color more or less banded or striped, which is found in large masses on Big Hill and Bear Mountain. Dark-purple to drab porphyritic metarhyolite with scattered white or cream-colored feldspar crystals or phenocrysts, which occurs in many places throughout the metarhyolite area and is particularly plentiful on Snaggy Ridge, is a more attractive rock for ornamental stone and has some resemblance to the porphyry of Egypt extensively used by the ancients for ornamental purposes. It is particularly well suited for pedestals or basal parts of monuments on which lighter-colored stone may be mounted, but it also makes a very satisfactory stone for carved inscriptions, as the cut lettering is light gray in contrast with the dark background. Although this rock is now obtainable chiefly in small slabs at the surface, larger masses of tabular form can be obtained by quarrying.

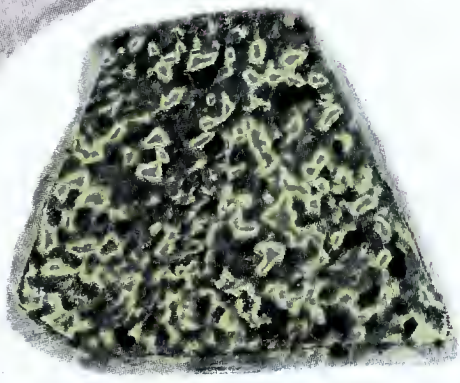
Other rhyolites still more attractive for ornamental purposes are a reddish-purple porphyry specked with white phenocrysts, from Corls Ridge near South Mountain Sanatorium, a bright-red, banded, dense, felsitic rock, which occurs at several places in Buchanan Valley south and southwest of Boyd School, a purple rock banded with green epidote near Piney Mountain, and other bright-colored metarhyolites with light bands or streaks, from Corls Ridge. See Plates V, VI, and IX. The extent and thickness of these rarer varieties of metarhyolite have not been determined, and before they can be regarded of commercial value it must be determined whether they can be had in blocks of size suitable for monuments.

A beautiful breccia of angular dark-red felsitic rhyolite fragments in a lighter matrix, obtained from the metarhyolite adjacent to a



A

B

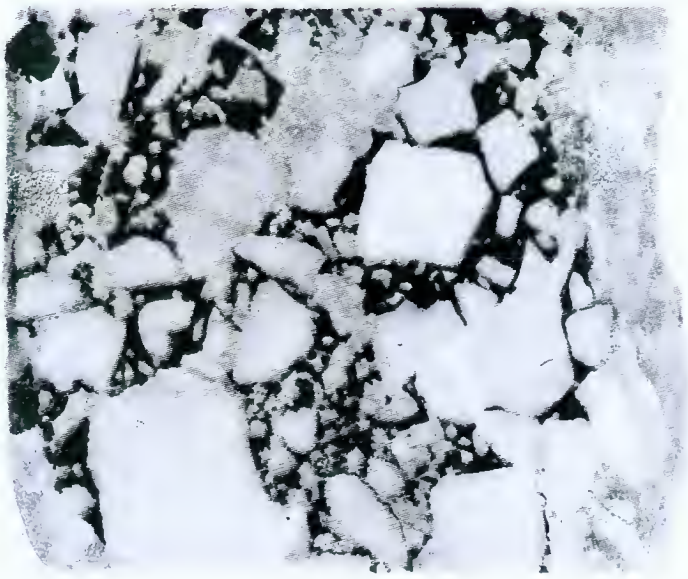


C

A. Deep-red, slightly laminated porphyry near South Mountain Sanatorium.
B. Catseye rock. Metarhyolite with green and pink concentric spots. Old Bingham copper mine.
C. Finely mottled green and gray metabasalt spotted with red. Near Gladhill station.

A

B



C

A. Red metarhyolite breccia in reddish-gray matrix. Two miles east of South Mountain Sanatorium.

B. Pinkish diabase peppered with black. Fox Hill east of Cashtown.

C. White marble breccia in dark-green chloritic matrix. Near York Springs.

Plate VII

A. Light-green metarhyolite with dark-green patches and burnt orange streaks. Old Bingham copper mine.

B. Mottled flesh-color and light-green metarhyolite. Old Bingham copper mine.

small greenstone area 2 miles east of South Mountain Sanatorium, is a rock worth quarrying for ornamental stone if it can be obtained in large masses. Although only one ledge of it was seen, it probably has considerable extent along the strike of the rocks and sufficient thickness to quarry, and it is believed that in depth it will be less shattered than it is at its outcrop. It is of fine even grain and takes a good polish. (See Pl. VI.)

The most promising ornamental rock in the area is an altered rhyolite found in the new open cut of the National copper prospect, old Bingham mine, 1 mile north of Gladhill station. It is mottled light-gray and pale pink or flesh color, splotched with white and bright green, in endless variety of forms and shades of color. A mottled-green rock with large round amygdules filled with a delicate pink or flesh-colored material with a bright-green center may appropriately be called "catseye" stone (See Pl. V.) Some of the green rock is splotched with bright orange. The metarhyolite is of unusually fine even grain so that it takes a high polish. It is illustrated in several plates. The rock at present on the dump of the old copper mine is so shattered by blasting that it is difficult to judge whether slabs and masses of sufficient size for commercial use can be obtained, but the rock is of so unusual and attractive appearance that it is well worth careful prospecting for this purpose. Even if only small blocks can be obtained the stone may be used for small articles like clock cases, tops of small stands and tables, paperweights, and possibly for art jewelry. The quarried product could be readily hauled down grade over good roads from the old mine to Iron Springs station on the Western Maryland Railroad, a distance of only 2 1/2 miles, where it could be shipped to market.

The metabasalt also contains rock of pleasing color and fine grain which can be highly polished. One kind is light-green epidote rock finely mottled with dark-green and gray and blotched with reddish yellow spots caused by a blending of red copper oxide and green epidote; another is dark-gray with light-green spots and minute bright-red specks in great variety. It occurs at many places in the greenstone areas of pre-Cambrian rocks of South Mountain, but specimens that have been tested by polishing were collected from the railroad cut southeast of Gladhill station and from the old Reed Hill copper mine at the head of Copper Run. Small pieces that are especially attractive might be cut into stones for arts-and-crafts jewelry. (See Plate IX.) Light-green epidote rock with small flecks of native copper which resemble gold when polished are also attractive for this purpose but the copper quickly tarnishes and becomes dull.

Diabase from several of the quarries near Gettysburg has been dressed and worked for tombstones and cemetery monuments, and

A. Banded deep-red metarhyolite. Near South Mountain Sanatorium.

B. Banded buff to white marble. Near Irishtown.

that from Peitler's quarry has been polished for this purpose, but the polished stone is rather dark and unattractive. Diabase from McKee Knob near Fairfield and from Fox Hill east of Cashtown is of lighter shade and has a pinkish color due to the larger amount of quartz and pink feldspar and is a more attractive stone for ornamental purposes, but it is not known to have been tried commercially. A polished specimen of the pink diabase from Fox Hill, illustrated in Plate VI, is of pleasing appearance. Although such rock must compete with the well established pink granites of the trade, it ought at least to find a local market as monumental stone.

Fine-grained milk-white marble of good quality which takes a fine polish occurs in several of the quarries around Bittinger but it is at present burned for lime. Although it can probably be quarried in larger masses than those obtained in the quarries at present and the rock will not be as badly jointed at depth as it is at the surface, the land is so flat and low that the quarries are now troubled with water and deep quarrying would be expensive. Even though the color and grain are good, it probably can not be quarried profitably for marble.

A breccia of angular fragments of similar fine-grained white marble in a dark-green matrix was obtained from Menges quarry 2 miles northwest of York Springs. It appears to occur in large masses at the quarry but its extent is not known. If it is in commercial quantities, it ought to find a good market for it makes a very handsome ornamental marble when polished, as shown in Plate VI.

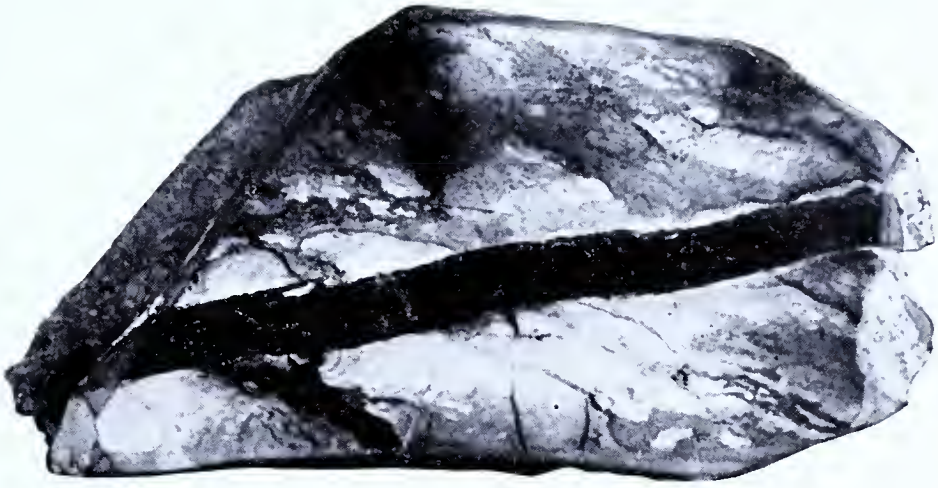
Some of the limestone which underlies the Triassic red sandstones along its eastern margin is tinted a delicate pink and buff, and in the quarries east of Irishtown very pretty banded marble of this kind has been taken out but has been used for lime burning. It takes a good polish (Pl. VIII) but as the rocks are vertical and the colored marble probably does not extend down more than a few feet, the amount of suitable marble is too small to be of commercial value.

Triassic limestone conglomerate has been quarried at Point of Rocks, Maryland, for marble which has been used for interior decoration, marble columns, and table tops under the name Calico or Potomac marble. The marble columns in statuary hall in the national capitol at Washington are a notable example of the use of this rock. Its effect is not very pleasing, however, and the stone is not popular for ornamental purposes today. The same kind of rock occurs near Fairfield in Adams County but has not been quarried for this purpose nor tested by polishing. Most of the rock seen there was of unattractive color.

CRUSHED STONE.

The crushed stone business is one of the largest mineral-product industries in the county. Besides the normal demand for crushed

Plate IX



A. Purple to pink metarhyolite with green epidote band. Southeast of Piney Mountain.

B. Green metarhyolite with burnt orange splotches. Old Bingham copper mine.

C. Dark-gray porphyry with light-pink spots. West slope of Green Ridge south of Gettysburg pike.

stone in the general improvement and maintenance of the roads of the State, a large quantity has been used by the Government in constructing the fine macadam roads of the Gettysburg National Military Park. The increasing substitution of concrete for building stone in the construction of buildings, foundations, roads, and other engineering projects has also greatly increased the demand for crushed stone. Most of the kinds of rock that are quarried for building stone and lime are also suitable as crushed stone for use as road material, railroad ballast, and concrete, and many of the quarries that produce crushed stone for these purposes are described under the previous heading "Building stone" and a later heading "Limestone." The following table shows approximately the amount of crushed stone produced in the county in the last few years. These figures do not include the production of many small operators whose output is consumed locally and of which no report is made.

Stone produced in Adams County, Pa., 1913 and 1920-1923.[1]

(Quantities in short tons.)

	1913	1920	1921	1922	1923
Crushed stone (road metal, ballast, and concrete)					
Diabase	2,000	22,000	----------	13,250	12,000
Limestone	54,300	33,000	63,650	51,130	57,300
Other limestone*	54,450	102,000	101,000	218,170	294,000
Granulated greenstone	†	16,220	22,100	29,800	29,630

[1] Prepared by A. T. Coons, U. S. Geol. Survey.
* Includes material used for flux, lime burning, agricultural purposes, paper manufacture, and filler in paints and colors.
† Statistics not available.

Triassic diabase is the rock that was used in the construction of most of the fine macadam roads of the Gettysburg Military Park. The Biggs quarry within the military reservation half a mile south of Cemetery Hill, supplied most of this crushed rock up to 1916. This material is of lighter color than the quarried blocks and the roads are light gray. The rock at the Biggs quarry is thinly sheeted and breaks into readily handled masses when blasted. These masses when reduced by sledge hammer to 10-inch size are passed through a Blake crusher, and are screened to assorted sizes for the different layers of the road. The wearing quality of the diabase is excellent, as shown by the test of this rock from Granite station, given in the appended table, page 27.

Dense dark Triassic argillite (shale hardened by the chemical action of heated mineralized waters that accompanied the intrusion of diabase) has been quarried at several places near Gettysburg for road material and is used on many of the roads in the vicinity. The State road to Carlisle was constructed of it, and the government roads in the Gettysburg Military Park have been largely constructed of it since

1916, and it is now extensively used in road repairs. It is much cheaper to quarry and prepare than the diabase, and makes a fairly good road bed, but it is not so lasting.

A large quarry adjacent to the Harrisburg road on the east face of Barlow Knoll, 1 mile north of Gettysburg, has been idle many years. In 1908 it was shallow pit, 150 feet long, with a face 15 feet high. It was formerly equipped with crushing and screening machinery. The rock is a dense blue-gray baked shale which crushes readily to irregular fragments. This road material was used on local roads.

Since 1917 a large amount of broken stone has been obtained at Smith's quarry, on the west side of Benner Hill, 1 mile east of Gettysburg. In 1924 the quarry face is 38 feet high and 300 feet long. It is at present operated by T. and M. E. Farrell. The quarry rock is chiefly hard dark-red to dark-gray shale or argillite altered by the intrusion of the large diabase sheet just south of the quarry. There are also some dense light-buff sandy beds. Green epidote coats the joint planes and occurs in small nodular masses and small veinlets. The rock in the quarry dips 30° NW. and the section is as follows:

Section at quarry 1 mile east of Gettysburg.

	Feet.
Porous crumbly buff baked sandstone.	2
Thinner bedded dark argillite, joints stained with epidote.	20±
Buff hard baked shale, some sandy, some fine even grained, with round green epidote nodular masses.	3
Dark argillite with epidote blebs and coating on joint planes.	20±
Very massive thick-bedded dark argillite, with epidote blebs.	15±
Buff even-grained baked sandy shale.	2
Dark argillite with epidote blebs and coating.	10±

This quarry employs 14 to 20 men and produces crushed stone for road metal and concrete. A single Ingersoll-Rand steam tripod drill that has been used by this company for 10 years is still in operation. The rock is crushed in a Champion No. 4½ jaw crusher, and screened to three sizes in an 8 foot rotary screen.

At Zora, 3 miles northwest of Emmitsburg, Md., the baked Triassic shale is extensively quarried for road material by Herbert L. Ginzell. The rock is a dark purple shale baked hard by the large diabase mass exposed across Toms Creek. Several beds of dense argillite, 3 feet thick, are quarried and used chiefly for road repairs. The plant consists of a crusher, pan elevator, rotary screen, storage bins, and a portable engine. The power from an overshot water wheel is also utilized.

Metarhyolite, a pre-Cambrian lava, has been quarried for road material at several places along the Chambersburg pike where it crosses South Mountain and also along the Shippensburg pike, 2 miles northwest of Arendtsville. The rock is very fragile and breaks readily into small angular fragments suitable for road material, but it does not bind readily. Samples from Menallen township in the northern part of the county were tested for wearing qualities, and the results are given in the table on page 27. Metabasalt, reported from Floradale but probably coming from the pre-Cambrian metabasalt or greenstone area 3 miles to the northwest, has also been tested and the results given in the table. Its cementing value is very high and its coefficient of wear also high. It, however, is so tough and hard that it is expensive to work and crush.

Slate or schistose sandstone is quarried for road material to a small extent in the southeastern part of the county and is used on the roads around Hanover and Littlestown. The Hostetter quarry, 2 miles south of McSherrystown, is a large shallow pit in dark-gray to rusty slaty sandstone. The rock is hard and durable, and breaks into angular fragments. Some of this rock is used for foundations. It is locally used for road material, but does not bind well. Tests of this rock are also given in the table on page 27. Road material was also obtained from Stoner's quarry, just east of Sells station on the Pennsylvania Railroad. This quarry was operated part of the time by the Hanover and Littlestown Turnpike Co. for the construction of the road. The rock is a dense dark-blue glistening sandy schist or slate, strongly jointed and breaks into irregular angular fragments, but weathers into shaly fragments. One mile southwest of Littlestown several small quarries were opened in this rock, and in 1922 one was operated by Daniel Beachtree for road material. The rock is a much-jointed gray sandy schist or sandy slate. In the Beechtree quarry the rock is so broken and slickensided that it needs little crushing. It is stained green and purple, so that it is distinguished with difficulty from the adjacent Triassic sandstone. The quarry was equipped with an inclined cable way from the quarry to the jaw crusher, with portable engine, pan elevator, rotary screen, 3 storage bins, and belt conveyor. The quarry was later operated by the Littlestown Stone & Products Co. but was idle in 1924.

In the southeastern part of the county limestone, particularly the impure earthy limestone quarried at McSherrystown and at several other places southward to Littlestown, was extensively used for road material and for ballast on electric and steam railroads. Tests of this limestone for road material are shown in the table on page 27. The dolomite and impure layers interbedded with the high-calcium limestone extensively quarried for lime and flux in

the vicinity of Bittinger are also crushed for road material and shipped by rail to distant points. Detailed descriptions of these quarries are given under a later heading, "Limestone." The binding quality of limestone is superior to that of most other kinds of rock, as shown in the table below. A sprinkling of asphaltum binder on the surface of a macadam pavement of any kind of rock, however, improves its binding qualities, and makes it waterproof and more enduring, as it keeps the finer particles from being blown away or from being sucked up by the automobile tires.

The quartzite quarried in the hill south of Bittinger is especially suitable for railroad ballast as it naturally breaks up into cobble-size fragments and is conveniently located on the railroad. Blocks of desirable size without crushing can be had at the surface and to considerable depth. It might also serve for the first course or foundation of macadam pavements. Similar broken quartzite occurs on the surface of the sandstone hills just east of Bittinger.

In the following table are presented facts regarding the hardness, resistance to wear, and binding qualities of various rocks from Adams County, tested in the Office of Public Roads and Rural Engineering, Department of Agriculture, Washington, D. C. In the table, hardness is a test of resistance to wear by abrasion; toughness of resistance to breaking by impact; French coefficient of wear is a combined test of abrasion and impact; cementing value is a test of its binding power with a water bond.

Physical tests of road-building rocks of Adams County.

By Prevost Hubbard.[1]

Locality	Character of rock	Per cent of wear	French coefficient of wear	Hardness	Toughness	Cementing value
Bittinger	Limestone	4.9	8.2	14.2	9	64
Hanover (near)	Limestone	4.1	9.7	16.0	7	22
Oxford township	Dolomite	3.9	10.2	17.7	16	42
Hanover (near)	Marble	4	16	14.7	8	20
Hanover (near)	Marble	5.8	6.9	13.3	3	21
Hanover (near)	Marble	5.1	7.9	11.0	6	66
Unknown	Siliceous limestone	3.5	11.2	17.7	9	24
Bittinger	Feldspathic sandstone	3.7	10.8	12.2	7	48
Berwick township	Quartzite	4	10.1	18.3	5	4
Littlestown	Slate and chloritic schist			11.1	12	27
Littlestown	Slate and chloritic schist			1.1	7	101
Hanover (near)	Slate and chloritic schist	6.6	6.1		11	46
Menallen township	Metarhyolite	2	19.8	19.6	4.2	13
Menallen township	Metarhyolite	1.9	21.1	19.5	3.4	22
Floradale	Metabasalt	2	20.4	18.2	9	260
Unknown	Metabasalt	2.9	13.8	17.0	10	500
Granite	Hypersthene diabase	3.8	10.5	18.7	12	15
Granite	Gabbroitic diabase	2.5	16.0	17.9	8	20

[1]The result of physical tests of road building rocks, U. S. Dept. Agr., Bull. 370, 1916, p. 59.

GRANULATED GREENSTONE.

Granulated greenstone is used in the manufacture of roofing material. Greenstone is selected for this purpose for the reason that a substance having a natural permanent green color is desired. Although this industry is a relatively new one, a considerable demand for the product exists and several plants are in operation in the county. A large quantity of the greenstone becomes pulverized in the grinding process, and this by-product is now used as a greenish filler in composition stone and flooring.

The first plant to be operated in the area was that of the Advance Industrial Supply Company of Chicago at Gladhill station on the Baltimore and Harrisburg division of the Western Maryland Railroad, now Greenstone postoffice. The plant is at the end of a long railroad cut and at first only the schistose greenstone masses from the dump of the old cut were crushed. When that was exhausted the adjacent bed rock was used. The rock is crushed in the plant to granules ranging in size from that of a wheat grain to a flaxseed, different sizes being used for different grades of product. The greenstone granules are shipped to the company's manufacturing plant in Chicago where they are spread thinly over the surface of bituminous or asphaltic paper roofing material. Some of this is cut into long sheets and rolled up like ordinary roofing paper, but most of it is cut into smaller sizes to imitate slate and shingles. The coating of greenstone particles gives the product a natural permanent color, and is fireproof from sparks on its surface. Two carloads of crushed rock a day were reported to have been shipped from the Gladhill plant to Chicago at the time of visit. Considerable fine dust is produced by the crushers and it is sucked out by air fans and is caught in bag collectors. At first this dust was dumped on the waste heap with fine screenings, but later a use was found for this by-product as a colored filler in artificial stone, cement, flooring, and rubber. The mill is equipped with gyratory crushers, rolls, and cylindrical screens, and the product is marketed at 10 to 34 mesh.

Greenstone granules have been produced by several other plants in the county. The Blue Mountain Stone Company of Hagerstown, Md., opened a quarry in the valley of Miney Branch southwest of Gladhill station. Quarrying was begun just east of and below the railroad track, where the crushing plant is located. The stone proved unsatisfactory, being rust stained and soft at the surface and bluish colored blotched with red deeper in the quarry. The quarry was extended eastward to the bottom of the valley where better rock was encountered but it is there covered by thick overburden. The quarry face when visited in 1920 was 30 feet long and 20 feet high in good grade rock. The quarried material was hauled in cars on a double-track tram 800 feet up the slope to the mill,

which was equipped with two gyratory crushers and two roller units.

The Green Roofing Stone Co., also of Hagerstown, Md., opened a quarry 200 feet south of that of the Blue Mountain Stone Co. midway on the slope. A quarry face 20 feet high exposed hard ledges of good-grade greenstone almost free from overburden. The quarried rock is carried by tram to the mill in the valley bottom, which is equipped with gyratory and disk crushers, rolls, and screens. The ground product first was bagged and hauled by truck to Charmian, less than a mile distant, where it was loaded loose in box cars. Later a 900-foot belt conveyor was installed which delivers the product to bunkers on the railroad on the mountainside above the plant. In January, 1922, the Green Roofing Stone Co. combined with the Blue Mountain Stone Co. and has since operated under the latter name. The product is marketed in one grade only, 10 to 60 mesh.

The Standard Stone Products Co., of Granville, N. Y., opened a quarry and built a plant at Iron Springs, which was operated for three years prior to 1921 but has since been idle. The quarry, which is about 100 feet long and 40 feet high, is 60 feet above the railroad track, and a gravity surface tram conveys the quarried rock to the mill, which is directly below the quarry and on the railroad. The mill is equipped with one large gyratory crusher, 4 roller mills, 5 Newago screens, and an air-separating system. This property was reported in 1922 to belong to the Shelden Slate Products Co., Granville, N. Y.

The schistose greenstone is chiefly used for this purpose because it can be crushed more cheaply than can the compact variety of greenstone and also because the resulting fragments are flatter and adhere better to the matrix. Large quantities of schistose material similar to that worked at the railroad cut at Gladhill station are available on both sides of the cut and at many other places in South Mountain. The areas of greenstone, much of which is schistose, are shown on the map, Plate I. Many of these deposits are so far from the railroad that at the present price, they probably have no commercial value.

LIMESTONE FOR LIME AND FLUX.

Limestone has been extensively burned for lime in the lowland around Bittinger in the southeastern part of the county. The output of the limestone quarries in Adams County for five years is given in the table on page 24.

The middle formation of the group of limestone in the vicinity of Bittinger contains thick beds of almost pure calcium carbonate which can be burned to high-calcium lime suitable for building plaster. Beds of dolomite interbedded with the pure limestone are

generally quarried for crushed stone. The rock layers in many of the quarries stand nearly vertical, and the depth to which quarrying can be carried economically is not great because the limestone occupies a flat lowland, and water from springs, streams, and rain rapidly accumulates and fills quarries and pits to the ground-water level, which is approximately the general surface of the lowland. On account of the few natural rock outcrops in the lowland it is difficult to find the high-grade limestone, and most of the quarry sites were determined from a few natural exposures, so it is probable that high-grade limestone occurs at many places beneath the cover of soil in areas between the quarries. The surface distribution of the formation which contains the workable beds of high-calcium limestone is indicated on the accompanying map, Plate I. The outcrops of the limestone are nearly everywhere covered with soil to a depth of several feet, enough to conceal the rocks but in general not so thick as to make the cost of stripping excessive.

The quarry formerly owned and operated by John R. Bittinger of Hanover but now owned and operated by the Bethlehem Mines Corporation of Bethlehem, Pa., is the largest quarry in the area. The quarry is at the end of a railroad spur northeast of Bittinger station on the Baltimore & Harrisburg division of the Western Maryland Railroad. The large quarry west of the Hanover pike is connected by a tunnel with another east of the road. To the north several large holes about 50 feet deep that were formerly worked are now filled with water. The large quarry opening is about 800 to 1,000 feet in diameter and about 50 feet deep. The newer quarry from which all production was coming in July, 1924, is about 500 feet long and 50 feet deep. The stripping is done by steam shovel and dragline excavator and the dirt is carried by train to a distant dump. The rock is drilled by a churn drill and is blasted to the floor of the quarry where it is handled by a Bucyrus steam shovel. Tram cars carry the rock up inclines to the crusher, an Allis-Chalmers gyratory of huge size. A tram car load of 15 to 20 tons does not half fill it. The rock is broken to 5-inch size. Crusher and hoisting equipment are electrically operated. The rock consists of a mixture of blue, fine-grained limestone and white crystalline marble, both high-calcium lime-rock, and granular gray dolomite. These rocks are intricately mixed, the dolomite and the pure limestone being not only closely folded together but apparently they also grade laterally into each other. The white marble is apparently a more crystalline form of the blue limestone, and they blend into each other irregularly. On account of these lateral changes of character the bedding is difficult to determine, but the general strike appears to be N. 65° E. and dip 75° SE. High-calcium rock seems to be largely replaced by dolomite in the northern part of the quarry. The rock is strongly jointed by planes that strike N. 25° E. and

dip 80° SE. When operated by John Bittinger, the high-calcium limestone was burned to lime and shipped to eastern cities for use in paper manufacture and for building purposes. Eight kilns were in operation in two sets of 4 each, one set charged with alternate layers of fuel and limestone, the other set burned by flame from separate coal furnaces. The Bethlehem Mines Corporation has abandoned the kilns and uses the rock for flux which it ships to its own iron furnaces at South Bethlehem. The light-colored dolomite which is quarried with the high-grade rock is crushed, screened, and sized for road material and railroad ballast. The limestone dust is saved and mixed with screenings as a top dressing for roads. The Bethlehem Co. has erected large elevated bins from which the rock is delivered by gravity into freight cars on the siding. Well-kept lawn and flower beds are an unusual setting for the crusher and bunker houses.

Steacy and Wilton of Hanover and Wrightsville, Pa., have a large plant at Bittinger station. A large new quarry has been opened west of the old quarry which was over 30 feet deep when abandoned and is now full of water, although its walls are largely of high-grade rock. The new quarry is about 600 feet in diameter and 65 feet deep. It is largely in granular white marble irregularly mixed with dark and light blue and dull-gray fine-grained limestone, both high-calcium limestones. This high-grade rock is said to run 99.5 per cent $CaCO_3$. Dark-blue to gray dolomite borders the pure rock on the north and apparently also on the south. At the west end of the quarry the bedding of the dolomite is clearly shown by bands of impure limestone which strike N. 60° E. and dip 70° NW. Dolomite also occurs on the southeast wall of the quarry and extends into the southwest wall of the old quarry. Besides four old stone kilns that are still used, two modern steel kilns are in operation. The high-grade lime produced is used for finishing wall plaster and in paper manufacture. Some discolored lime is sold for fertilizer. The pure rock is also sold for flux. The dolomite is crushed for road metal. This firm was employing 70 men in July, 1924, and could produce 300 tons of crushed stone daily with a Champion No. 5 and Trayler 18 by 24 inch jaw crusher. Four flame kilns and six pot kilns are burning agricultural, building, and chemical lime. A Clyde hydrator yields about 45 tons of hydrated lime daily.

The Max Hoke and Son quarry is on a short railroad spur 1 mile south of Bittinger station. It is a large pit about 300 feet square and 20 feet deep. Most of the rock is high-calcium white marble and sheared light-gray fine-grained limestone. The north face of the quarry is dark dolomite with lumpy structure, and at the contact the limestone is highly brecciated and veined with calcite, evidently along a fault. Two steam drills were in operation at the time of

first visit in 1908, and the quarry was kept dry by a large pump. Tram cars conveyed the rock to the mill, from which a trestle 50 feet high led to three kilns, which are of stone with high smoke stacks. The interbedded dolomite and impure thin-bedded limestone were crushed in a large mill equipped with pan elevators, and after screening out 3 sizes, the pulverized limestone screening was saved for use in making cement blocks. The plant has since shut down and the quarry is full of water. This flooded quarry is now the site of an ice manufacturing plant.

A quarry just north of the Hoke quarry, newly opened when seen in 1908, had high-grade rock at the surface but it passes into dolomite at shallow depth and was abandoned.

One mile north of Bittinger on the Hanover road is the Shriver quarry. At the time of visit in 1908 it was operated by Jacob C. Shriver. Quarrying was done with a steam drill and the plant consisted of three stone kilns and a rock crusher. Mr. Shriver was succeeded by J. H. Maul & Sons of Hanover, and more recently E. M. Bittinger of Hanover operated the quarry for 5 years for crushed stone. In 1924 about 10 men were employed at this quarry. The high-grade white marble and gray limestone are limited to the north face, the larger part of the quarry being composed of dolomite and impure limestone. The contact strikes N. 20° - 50° E. and dips 60° NW. Two old abandoned holes are adjacent to the active quarry.

Numerous old quarries from which the pure limestone has been removed to considerable depth are abandoned and full of water, although high-grade rock is still exposed in the walls of many of them and probably extends under the adjacent lowlands. The impure limestone and dolomite in these old quarries were generally untouched, as in earlier days there was not sufficient demand for crushed stone to warrant quarrying them, and the layers of these impure rocks stand up as high pinnacles and walls in the abandoned flooded quarries.

Several quarries more than a mile west of Bittinger were operated spasmodically and produced chiefly agricultural lime that was used on the adjacent shale lands to the west. The beds are vertical and the impure rock is left standing as walls between the quarry trenches. Some high-grade limestone is still exposed in the quarry faces. In the vicinity of Centennial, 2 miles west of McSherrystown, there are several large quarries from which large quantities of agricultural lime and broken stone have been obtained. The largest of these, the Pullman quarry, is just west of the village. It was operated by the Centennial Lime & Stone Co. before 1916, and later by E. M. Bittinger, but has been idle since 1916. It is a long, narrow quarry that follows the purer limestone beds, which are about 100 feet thick and strike S. 25° W. and dip 60° NW. Pure light-blue limestone banded

with dark layers is the chief rock quarried. Some of these beds are oolitic, others are finely conglomeratic, and some are highly brecciated and veined with coarsely crystalline white calcite. There are also white saccharoidal marble beds 20 to 30 feet thick. These pure beds are probably at the same horizon as those around Bittinger, although they differ somewhat in appearance. The lime that was burned in the three stone kilns was largely used for fertilizer on the Triassic shale lands to the west. Another rather large quarry in similar rock just west of the Pullman quarry was operated by Harry Strine. Nicholas Gebhardt has more recently produced both crushed stone and lime from the Pullman quarry and another quarry just north of the public road.

South of an east-west line through Centennial and Edgegrove the limestone is not pure enough to be burned into high-grade lime, and the lime produced from quarries located there was used for local agricultural purposes. A large quarry in the northern part of McSherrystown formerly produced burned lime for agricultural purposes in two stone kilns but later produced chiefly crushed stone for roads and ballast, and rubble for foundations. The quarry is over 50 feet deep, about 300 feet across, and extends several hundred feet along the strike, in a southwesterly direction. The rock is largely a dark, slaty, fine-grained limestone with some beds of white crystalline limestone and limestone conglomerate, much of it veined with calcite. When visited in 1920 it was equipped with a Blake crusher, pan elevator, and screens, and supplied much of the ballast for the electric railroad to Littlestown. There are small quarries in the same kind of rock at many places to the southwest, particularly in the extreme southern part of the county near Littlestown, but most of them are abandoned or are operated only occasionally. One of these was operated by O. H. Parr in 1921, who burned some lime. W. V. Sneeringer has produced crushed stone at a quarry $\frac{1}{2}$ mile northwest of Littlestown since 1920. The stone is thin-bedded dark slaty limestone which is brittle and breaks readily into suitable fragments for road metal. The quarry was in active operation in 1924, when it was 50 feet deep and about 100 feet across, and was equipped with bucket tram, Pace crusher (10 by 20 inch), rotary screen, and bins, and a compressed air jackhammer drill. All machinery is operated by electricity. Ten men are employed at the quarry.

The limestone in the vicinity of Fairfield has been quarried and burned for agricultural lime for local use at a few places. A quarry 1 mile northeast of Fairfield was operated by S. S. McCleaf until 1915 for the production of lime. It is in Triassic limestone conglomerate. The elongated pit, now overgrown, was 15 feet deep and the limestone was burned in three shaft kilns. Many small depres-

sions in the lowland in this vicinity mark places where limestone was formerly quarried for lime but rock is no longer exposed there. Some of these pits are in Triassic conglomerate but others are in the underlying Paleozoic limestone.

Limestone was also quarried at several places near York Springs. The Gardner quarry, $\frac{1}{2}$ mile east of York Springs, was operated in 1907 by Horace Smith, and more recently by the State Highway Department. Massive beds of white, gray, and pink crystalline marble were quarried, some of which was brecciated. It is overlain by Triassic red sandstone with limestone conglomerate at the base, and is stained pink from the red sediments. This quarry has been idle for several years.

Judge Geo. H. Trostel quarry is 2 miles northwest of York Springs on the road to Idaville. It is in a field on the north side of the road, has a face about 25 feet high and 300 feet long, but has not been worked in 15 years.

The Emanuel Menges quarry is near the road crossing southeast of Snyders Hill and $2\frac{1}{2}$ miles northwest of York Springs. The quarry is about 50 yards in diameter and has been idle so long that it is now completely overgrown.

Both these quarries are in massive light-gray magnesian limestone. Some of the rock is a brecciated white marble cemented by green limestone, and makes a handsome ornamental stone when polished (see Plate VI). The limestone is overlain by red Triassic sandstone and intruded by diabase.

Two other quarries are about 2 miles northwest of York Springs on the Carlisle pike. The Lears quarry was operated for making building lime but has long been idle. The rock is a massive crystalline limestone with fine black seams. The Bushey quarry has more impure rock, is streaked with dark slickensided layers, and veined with green. It is intruded by diabase. The face is 110 feet long and 40 feet high. The rock is closely and irregularly jointed and was burned for lime many years ago in a crude kiln, the ruins of which are near. A stone crusher outfit was brought to this quarry in the spring of 1924 preparatory to producing road metal.

SLATE.

Sericite slate of light-gray to dark-purple and dark-gray colors occurs near the base of the Cambrian formations. Its distribution throughout the county is shown on Plate I. The slate so far prospected is of no commercial value for roofing purposes and probably of little value for other purposes at the present time. The rock is a shiny, schistose, arkosic slate which splits readily into large slabs with rather smooth but irregular surfaces. Some years ago the Pine Grove Mining Co. opened a rather large quarry

(see Pl. X) in this formation on the east slope of Piney Mountain in the northern part of the county, and built a railroad connecting it with their furnace at Pine Grove. This slate is fine grained and of pleasing purplish color, ribboned by dark and light banding of sedimentary origin. At the outcrop, however, it is too soft and finely fissile for roofing purposes, but in depth it may become firm enough for some other uses. Blocks of thicker-bedded coarse-grained, sandy, arkosic slate from this quarry were formerly used to line the Pine Grove iron furnace. Later the slate was ground and used in making light-colored brick at the furnace.

Plate X. Slate quarry in lowest Cambrian rocks. East face of Piney Mountain.

Another outcrop of the formation was prospected some years ago by the same company on the Martin property, at the head of Mountain Creek Valley, on the lower east slope of Big Flat Mountain. The rock at the surface here is equally poor for roofing purposes,

as it splits into thin papery layers of low breaking strength. Similar rock occurs along the entire east foot of Piney, Pig Flat, and Snowy mountains, and of Green Ridge, but the slabby and slaty character are generally not well shown on the weathered outcrop. Somewhat similar rock occurs in the outlier of this formation at the southeast foot of Jacks Mountain, well exposed near Jacks Mountain station. None of this rock is of commercial value as slate.

Some volcanic sericite schist and schistose rhyolite also make a smooth slate that might prove of some commercial value. Most of the volcanic schist in Buchanan Valley is too uneven and crinkled for such use, but in the northern part of the county and in the adjacent part of Cumberland County several small quarries have been opened in the schist. Slabs of so-called "soapstone," which in some respects it closely resembles, were there taken out for local use. Probably sawed slabs of this rock may serve for use in sanitary fixtures, but it is not likely to successfully compete with better material already on the market.

A narrow band of sericite schist at the contact of the greenstone and rhyolite just east of Mount Hope has a smooth slaty structure and has been prospected for slate by a large tunnel. The rock is apparently a volcanic tuff altered to a schist by metamorphism through intense compression and shearing. The slate mined here is light-gray and is finer grained, firmer, and has a better cleavage than the metamorphosed arkosic slate opened by the Pine Grove Co. The rock, however, is apparently not satisfactory for roofing slate as it does not cleave readily and the prospect has been long abandoned. It is possible that mill block might be quarried and sawed into slabs for use in sanitary fixtures, table tops, wall trimmings, and other uses to which massive slate and soapstone are put. There is little probability, however, that any of the slaty rocks in the county can be commercially used for slate at the present time.

CLAY AND SHALE.

Clay and shale suitable for ordinary brick are plentiful in Adams County and high-grade paper and vitreous tile-clay is also known to occur therein. Although it is extensively mined in the adjacent part of Cumberland County, there is no recorded production of this high-grade clay in Adams County. The brick clay industry is centered chiefly around Berlin Junction, 1 mile southeast of New Oxford in the eastern part of the county. The production for Adams County in recent years was as follows:

Value of clay products made from clay and shale in Adams County, Pa., 1913 to 1920.

Year	Value
1913	$93,728
1914	81,205
1915	87,671
1916	102,811
1917	121,063
1918	119,148
1919	208,276
1920	272,039

Paper, paint, and ceramic tile clay.

A very pure white siliceous clay, suitable after thorough washing and filtering for use as a paper filler and in the manufacture of paint, white vitrified tile, and probably chinaware, is associated with the brown iron ores at many places along the west base of South Mountain and in certain limestone valleys within the mountains. In its crude form it is used to make light-colored buff brick, and a distinctive brick industry has thus been built up.

In the vicinity of Mount Holly Springs and in the valley of Mountain Creek, Cumberland County, a few miles north of the Adams County line, this white clay is of unusual thickness and purity, and has been extensively mined. A considerable thickness of clay was reported from many of the old iron workings of the Montalto Company at the foot of South Mountain, Franklin County, only a few miles west of the Adams County line, and also in a prospect near Black Gap just west of Caledonia Park, and 22 feet of white clay was reported to overlie the lump ore of Big Pond ore bank, Cumberland County, which is similarly situated along the northwest front of South Mountain. It is therefore reasonable to assume that white clay accompanies the brown iron ores under similar geologic relations in the valleys of Hosack Run, Conococheague Creek, and Mountain Creek where limestone is shown on the map, Plate II. However, large deposits are not to be expected in these narrow belts.

The clay is not a pure kaolin but is highly siliceous, as shown by the following analysis. The analysis is of a crude white clay from a mine in the valley of Mountain Creek a few miles north of Adams County.

Analysis of crude white clay from Henry Clay, Pa.

(W. T. Schaller, Analyst.)

SiO_2	69.61
TiO_2	.90
Al_2O_3	16.83
Fe_2O_3 (total iron)	.95
CaO	.11
MgO	1.51
Na_2O	.08
K_2O	3.41
P_2O_5	.14
Loss on ignition	6.35
	99.89

This shows a large excess of fine silica which probably occurs as very fine particles of quartz. The relatively high per cent of potash is due to the presence of sericite. In the manufacture of brick, tile, and chinaware this clay must be mixed in proper proportion with more plastic and fusible clays.

A fine-grained white sericite schist, derived from pre-Cambrian rhyolite by shearing and pressure, was opened for clay by the Central Mining Company near Latimore, in the north part of the county. The product did not prove entirely satisfactory for the purpose, probably because of the presence of scattered coarse grains of quartz which could not be economically removed, and operations were discontinued. Similar white to pale-green sericite schist of fine even grain in Buchanan Valley in the northwestern part of the county may prove of sufficient purity and fineness for this purpose, but it has not been tested or analyzed so far as known. The larger bands of these schists are shown on the sketch geologic map, Plate II.

White and colored ceramic mosaic floor tiles are made from white and light-colored clays from South Mountain by the Penn Tile Works at Aspers, in the northern part of the county. English ball clay was formerly mixed with the siliceous clay to give it plasticity and binding qualities but Florida or other domestic plastic ball clay is now used. Quartz was formerly obtained in the vicinity of Aspers, pulverized, and mixed with the clay to reduce the shrinkage during burning, but in recent years silica sand from Mifflin County has been substituted. White clay used in making white, cream, or light-buff tile is obtained from several places in South Mountain just outside of Adams County, and some from the Montalto region has been reported especially suitable for the purpose. The clay is thoroughly washed and sieved or filtered to the required fineness. Yellow and pink residual clays obtained in the vicinity of Aspers are used in the manufacture of red and other dark-colored tile. After silica is added in the proper proportion to give the required chemical com-

position and desired color, it is thoroughly mixed with water and forced through a 120-mesh sieve by pulsometers. The slip is then dried and crushed to a powder, and spread by hand into molds, where it is compressed by suitable presses. The molds are placed in saggars and are stacked in three tiers in a modern circular kiln and burned. These kilns, of which there are three, have a central draft with seven chimneys, and are fired from exterior fire boxes. They are $12\frac{1}{2}$ and $14\frac{1}{2}$ feet in diameter. The kilns are brought to a temperature corresponding to cone $9\frac{1}{2}$ or 10 (1300°-1310° C. or 2408°-2426° F.), which produces the desired amount of vitrification, and are kept at that temperature 6 days. The product is a vitrified ceramic floor tile of unusual high quality and good color. The tiles are packed in sheets of various designs and sizes, stuck on paper ready to lay. A patented white tile with delicate mottling or marbling, called litho-marble tile, is one of their unique and attractive products. The company employes 40 persons.

Brick and tile clay.

In this region bricks are made from residual clay in limestone areas, from soft shales and weathered schists, and from the siliceous white clay associated with the limonite ores of South Mountain. The soft red Triassic shales are used for brick at several places in the eastern part of the county, the largest industry being at Berlin Junction southeast of New Oxford, where three extensive plants are in operation.

Alwine Bros. of New Oxford have one of the largest brick plants at Berlin Junction, where the red shale is crushed in circular pans. The bricks are placed on iron-wheeled racks and dried in a steam-drier with an exhaust fan, and burned in five kilns. The plant has a capacity of 32,000 brick daily and employs 35 men. Staub's brick plant adjoins the Alwine pit on the north, and is similarly equipped with a modern kiln which uses air-dried bricks. W. H. Carbaugh of New Oxford has pits on both sides of the road still farther north, and has both air-drying and steam-drying facilities. These plants are conveniently located at a railroad junction and their products are shipped to many cities and towns in the region.

The Auburn Shale and Brick Company has a large brick plant comprising eight circular kilns in the northwestern part of Gettysburg and furnishes most of the brick for local use. The large shallow pit is dug in soft red shale of the Triassic. The Gettysburg Drain Tile Works also uses the Triassic shale. The plant is on the east side of town and employs 7 men. It has two down-draft kilns, 18 and $20\frac{1}{2}$ feet in diameter. The principal product is a 3-inch tile one foot long. The dry sheds hold 48,000 of these tile laid down, and an equal bulk of larger tile can be stored overhead.

Old kilns just north of Cemetery Hill in Gettysburg formerly got clay from the residuum of decomposed diabase, but the layer is very thin and was soon exhausted.

Thick clay, residuum from the impure limestone in the area south and southwest of Edgegrove, is of excellent quality for brick manufacture. It is not at present used for brick in Adams County, so far as known, but is extensively used to the east in the vicinity of Hanover. In these pits the clay passes downward into firm shale, representing leached shaly impure limestone, and finally into the solid limestone beneath. The shale is also used for brick. Shale beds interstratified in the limestone 1 mile north of McSherrystown are locally quarried for brick making.

The pure white siliceous clays associated with the ore in the old iron ore banks of South Mountain west of Adams County, more fully referred to under the previous heading "Paper and ceramic tile clay," have been extensively used in the manufacture of a superior grade of light-buff brick at Mt. Holly Springs. Such clays have not as yet been dug in this area. The light-colored sericite schist in the pre-Cambrian volcanic rocks has about the same composition as this siliceous white clay, except that it contains a little more potassium and silica, and can probably be used for the same purposes. Such schist bands in Buchanan Valley in the northwestern part of the county are shown on the map, Plate I, and some day may be utilized for brick. The sericitic sedimentary schist first quarried for slate by the Pine Grove Company, 2 miles west of Wenksville, was later used in making brick at the Pine Grove furnace.

VEIN QUARTZ.

Quartz has been quarried at several places in the northwestern part of the county and in the adjacent part of Cumberland county for silica (or "flint" as it is commonly called in the trade), used in crockery and tile manufacture. Quartz for this purpose must be free from iron and other impurities. Quartz veins are numerous throughout the area of volcanic rocks in the South Mountains and those that are most prominent at the surface are shown on the map (Pl. I). The veins are generally associated with soft sericite schist, and as this rock generally weathers readily, the loose residual masses of the inclosed quartz strew the surface and conceal the vein outcrop. The veins are about 1 to 2 feet thick, and masses several feet long are not uncommon.

Quartz veins are more plentiful in the extreme northwestern part of the county. The loose masses of residual quartz have in many places been collected from the fields and several years ago the best rock was picked out and hauled to a quartz mill at Aspers. Much of the field rock is stained yellow by the weathering of the contained

hematite and is discarded. Ledges of vein quartz have been opened in places by small pits where the fresh rock has been quarried. There are several pits and collecting grounds of surface rock in the vicinity of Wenksville and near Idaville. One of the largest quartz quarries in the county was the Moses Black quarry, 1 mile north of Wenksville. A large vein just south of Idaville was formerly extensively quarried and quartz is still exposed in the pits near Gardners station.

Several quartz veins occur on the north slope of Huckleberry Hill near Caledonia Park, and one of these was formerly extensively quarried and the quartz crushed at a mill at Black's Gap just west of the county. The old quarry is 20 feet deep and 70 feet long. This quartz has some hematite impurities in it and it must be carefully hand picked. Quartz was also formerly quarried from a vein above Hilltown and was reported to have been shipped to Columbia or Lancaster, Pa., for treatment.

Most of the quartz formerly collected in the region was hauled to Aspers on the Gettysburg and Harrisburg branch of the Philadelphia and Reading Railroad, and ground by the Columbia Flint Company, a branch of the plant at Columbia, Pa. This company stopped operation in 1919 and its kilns have been torn down. The method of treatment formerly employed is described as follows: The rock after being burned in four kilns for 24 hours falls to small lumps, and is carried by elevated tram to the mill, where it is fed into the chaser or first mill. Here heavy stone rollers on horizontal axles crush the rock to fine particles which become finer and finer as they work to the edge of the rotating floor and finally pass out of the mill. A pan elevator carries the product to the upper floor where it is screened, the tailings being delivered to a smaller mill of similar character on the lower floor where they are further ground to the required fineness. The dust is sucked out of the chasers by fans to protect the operators from inhaling it.

The screenings are pulverized in five horizontal cylindrical ball mills. The cylinders are about 10 feet long and 4 feet in diameter and are lined with hickory blocks. Imported quartz or flint balls were used in these rotating cylinders to crush the quartz. Importation of these flint balls was stopped by the war and domestic substitutes have been sought. Although most of those tried come from the western part of the country, pebbles of hard even-grained felsitic altered rhyolite from the New England coast are hard and tough and have been recommended as a fair substitute. After 6 hours grinding the product is pulverized so that most of it will pass through a very fine-mesh screen. The last of the 5 screens through which the powder passes is of silk or fine cloth.

Most of the pulverized quartz made by the Columbia Flint Co. was shipped to chinaware and pottery manufacturers but some was used in the manufacture of ceramic tile at Aspers. The company is reported to have stopped operations because the supply of suitable quartz near Aspers was depleted and because of competition with pulverized glass sand.

QUARTZ SAND.

Quartz sand for building and railroad purposes is obtained in the county chiefly from weathered Cambrian quartzite of South Mountain and from residual sand derived from it, but some is obtained from disintegrated highly siliceous limestone. Local deposits of other origin also occur.

The upper member of the Cambrian quartzites usually disintegrates readily into workable sand deposits. Sand obtained directly from the parent ledge is clean, sharp, and of excellent quality, but much of the sand that is dug is taken from the wash below the outcrop and is generally discolored by iron oxide and is not so clean. The sand is not pure enough in its crude form for glass manufacture, but if washed, or the fresh rock was crushed for the purpose, it might be suitable for this purpose. This Cambrian quartzite outcrops in the valley of East Branch of Little Antietam Creek, and at several places within the mountains, as shown on the map, Plate I. There are a number of pits on the west slope of South Mountain west of Adams County, whence it is hauled by wagon to the Cumberland Valley Railroad at Shippensburg and other towns. None have been opened in the county, except small pits worked for local use in building and for roads, chiefly because the areas of this Cambrian quartzite in South Mountain are too distant from the railroad for economically mining and shipping the sand. The Cambrian quartzites in the Pigeon Hills, in the extreme eastern part of the county, do not readily disintegrate into sand, but a little is dug for local use.

A very sandy limestone that weathers to a loose brown sand occurs at several places in McSherrystown and west of Brushtown in the southeastern part of the county. (See Pl. XI.) The sandy bed is interbedded with other impure limestone in this part of the county. At McSherrystown the sandy limestone has been leached of its lime at the surface, and is extensively quarried for quartz sand. The loose sand passes into firm sandrock at shallow depth, and this into unaltered blue sandy limestone at 20 feet depth, which is about the limit of workable material. The leached sandrock is easily broken up by pick and sledge hammer and rock crusher, and when screened makes a coarse building sand, deeply stained however by iron. The grains are apparently oolitic in structure and

were originally round, but are roughened and made irregular by partial solution in the disintegration of the rock. Four pits are located in the northern part of McSherrystown in the vicinity of the water tower.

Similar disintegrated sandy limestone forms a low ridge 1 mile west of Brushtown where sand is also quarried in several shallow pits. The rocks here strike northeast, and the sandy bed is evidently the same as and continuous with that at McSherrystown, but its outcrop can not be traced across the lowland where it is deeply weathered and covered with alluvium. At McSherrystown the bedding can not be discerned, but from its surface distribution the bed is apparently folded, for its outcrop swings around the east end of the large limestone quarry in the northern part of the town.

In the mountains southwest of Orrtanna disintegrated rhyolite composed of sand grains and clay has been locally dug for sand for building, but is of very poor quality. East of Gettysburg on the southern side of Wolf Hill disintegrated diabase composed chiefly of feldspar grains in clay has been similarly dug and screened, but it is a poor substitute for clean quartz sand. Better sand may be had from alluvium and terrace deposits along the larger streams, especially along the Conewago and Marsh creeks, and is at present locally used.

GRAVEL AND BOULDERS.

Gravel occurs in the flood plains and on benches along many of the streams in the county, particularly those within South Mountain and those which issue from it. The gravels range from coarse boulders in and near the mountain to fine gravel and sand several miles out in the valley. They are at present used only locally in the area.

Gravel suitable for road material and concrete is obtainable from the stream terraces and alluvial deposits chiefly along Conewago Creek but also along some of the other streams that head in the mountains. Close to the mountain the gravel is generally too coarse for such use. The boulders and cobble in the wash and talus from the mountains are used in many places for fences and stone walls, and the more attractive ones, such as those derived from the white and purplish quartzite, are used as ornamental rustic building stone. The "ironstone" boulders resulting from the spheroidal disintegration of Triassic diabase are much used for fences, and such stone fences in Gettysburg and vicinity formed the barricades used by both armies on Seminary Hill, West Confederate Avenue Ridge, and other hills on the battlefield.

The Triassic quartzose conglomerate along the east foot of South Mountain is mostly disintegrated and many of the foothills are

Plate XI.

A. Sheared rhyolite quarried for building stone. At the mouth of The Narrows, near Bridgeport.

B. Porous sandstone, derived from sandy limestone by leaching, quarried for building sand. The apparent bedding is probably schistose structure. McSherrystown.

covered with the loose quartzite pebbles and cobble from these beds. Some are suitable for concrete but in general they are too coarse for this purpose. They may be used as rustic building stones.

ABRASIVES.

Whetstone.

A fine-grained siliceous slate in the volcanic rhyolitic tuff and breccia of Buchanan Valley in the South Mountain makes a very serviceable whetstone. Although the rock has not been quarried on a commercial scale for this purpose, its qualities are locally well known and the stone has been used for this purpose by the inhabitants for many years. Samples taken by the writer proved to be of excellent quality. It is very fine even-grain, light-gray rock, easily worked, and even the surface material is usable for this purpose.

Rock suitable for whetstone is known to occur only near the head of the valley west of Brady school at the place shown on the accompanying map (Pl. 1), but rock of similar character that has not yet been tested is apparently present elsewhere in this belt of tuff and breccia which extends northeast and southwest of this place for a distance of 5 miles. Dark slates seen also in other belts of volcanic schist in Buchanan Valley were not tested for whetstone, and some of them may prove to be of similar quality.

As requests for information regarding fine-grained volcanic material of this character suitable for whetstone are occasionally received, it is believed that the deposit near Brady school would bear investigation and test on a commercial scale.

Garnet abrasive.

Garnet is a metamorphic mineral formed in limestone or calcareous sediments by the action of heated mineralized waters that accompanied the intrusion of diabase. Garnet is so hard that when crushed to the proper fineness it makes an excellent abrasive. Small nodules and masses of garnet are associated with magnetite in the ore deposits near Fox Hill east of Cashtown, and in other parts of the metamorphosed calcareous Triassic sediments in the western part of the Gettysburg lowland. Locally in this metamorphic belt, larger quantities of the mineral have been found and some of these deposits may possibly be of sufficient size to be of commercial value.

North of Fairfield, where the thick diabase stock and sill have intruded between the Paleozoic limestone and the Triassic sediments, the limestone has locally been extensively altered to garnet and the soil in the fields is filled with large and small masses of a dirty yellowish granular rock, which proved to be garnet. It can be readily distinguished from other rock fragments by its greater

weight. The mineral has been observed in fairly large quantity at two places. At the northwest foot of Sugarloaf, 1½ miles north of Fairfield, the soil of the fields is so filled with these residual garnet masses that they obstruct plowing. One and one-half miles farther north, on the slight rise in the lowland on the north side of Muddy Creek, the soil is similarly filled with garnet masses. The quantity of garnet float at these places is sufficient to suggest that a considerable body of the mineral occurs at the contact of the diabase and limestone, and if such is the case the deposit may prove of sufficient commercial value to be worked on a small scale. These prospective occurrences are indicated on the accompanying map, Plate I. The garnet masses can be readily crushed with a sledge hammer to fragments of suitable size to be ground for abrasive purposes. If the deposits should prove to be of insufficient size to warrant the construction of a mill on the ground, it might nevertheless be profitable to collect the loose material in the fields and ship it to Philadelphia or to some nearby place where suitable mills already exist.

ASBESTOS.

Although the geologic conditions and the rocks in the pre-Cambrian volcanic area of South Mountain are very similar to those in the province of Quebec, Canada, where high-grade asbestos is mined on a large scale, only small quantities of asbestos have been found in the pre-Cambrian greenstone of South Mountain, and probably there are no deposits of commercial value in Adams County. Several prospects have been opened in South Mountain and many other occurrences of the mineral in the county have been observed. These are indicated on the accompanying map (Plate I). The mineral is crysotile, a fibrous form of serpentine.

The best quality of asbestos obtained in the region came from a dike-like band of greenstone which crosses Corls Ridge a mile north of South Mountain Sanitarium, just west of the county line. This asbestos is cross fiber and fills small gash veins about one-half inch wide in the greenstone. Although the fiber is green and silky, it is so short and interlayered with quartz that it has no commercial value. Other specimens of silky asbestos were obtained from the Baker prospect shaft in the small greenstone area 2½ miles southeast of the sanitarium, at the western line of the county. Very thin veins of silky asbestos show in the Western Maryland Railroad cut near Charmian, in the southwest corner of the county. This has the appearance of a slip-fiber vein. Although the quality seems good the quantity at these places is very small and not of commercial value.

More brittle and less silky asbestos with much intergrown quartz was obtained from the narrow greenstone band at the head of Buch-

anan Valley 2 miles north of Newman school and at two other places farther north in Buchanan Valley on the greenstone area on which Boyd school is located. Small quantities of fairly good asbestos associated with quartz veins and sericite schist were collected at several places in the lens-shaped area of greenstone east of Wenksville. Brittle asbestos of rather long fiber fills a vein 4 inches wide in the narrow band of greenstone on the east side of Copper Run. It has so much quartz and other impurities intergrown that it also is valueless.

PIEDMONTITE.

Piedmontite, a rare mineral of interest to mineralogists and therefore of minor commercial value, occurs in the pre-Cambrian rhyolite in the county. It is a red epidote mineral of composition similar to the commoner green epidote, except that it contains manganese. Excellent specimens of the mineral were found in considerable abundance in the rhyolite near the greenstone contact at two places on the west side of Buchanan Valley (shown on the map, Plate I), and also on the west side of Piney Mountain. It has also been reported along the Western Maryland Railroad south of Charmian, near the south boundary of the county. The mineral fills thin crevices and gash veins up to one-fourth inch in thickness and several inches in extent. It has a deep rich-red color and a fine radiate fibrous structure. It is a hard compact mineral so that it takes a good polish, and since it has a deep-red color it may prove of value as a semiprecious stone as well as for mineral collections.

OIL AND COAL.

Although no deposits of these minerals have been found in the county and there is little hope that deposits of commercial value will be found, they have been prospected for, and are mentioned in order to discourage further search or hope of finding them.

A well was drilled for oil some years ago near the head of Little Marsh Creek in South Mountain. Nothing could be learned about the result of the boring, but the fact that the well was located in the pre-Cambrian volcanic rocks is sufficient to warrant the statement that no oil or gas was struck. If the well had been sunk in the red Triassic shales, this statement could not be made so positively, but there is little probability of finding oil or gas in paying quantities in any of the rocks in the county. Both the character of the rocks and their structural relations are unfavorable for the occurrence of these products.

A thin bed of coal was reported to have been found in the red Triassic sandstone at Aspers. The reported opening had not been preserved, nor had samples of the coal been kept. No coal seams

were observed by the writer in the Triassic of this region. Although workable coal beds are known to occur in rocks of this age in Virginia and small chunks and very thin seams of coal have been found in similar beds farther east in Pennsylvania, the rocks in Adams County have been so thoroughly examined that there is no possibility that workable coal beds will be found there.

METALLIFEROUS DEPOSITS.

COPPER.

Copper in the pre-Cambrian volcanic rocks.

Mode of occurrence.—Copper, principally native, occurs in many places in the greenstone or metabasalt of South Mountain. It is found in little grains and wires and in lumps seldom over an inch in size, although much larger lumps have been reported and are on exhibition at the mines. Some of the copper particles are surrounded by cuprite (red copper oxide) and a yellow material whose color is due to an intimate mixture of the red cuprite and green epidote. At the surface of the bedrock and to considerable depth along joint planes the copper is altered to malachite and azurite (green and blue hydrous copper carbonates), which stain large areas of the adjacent rock and give the impression of deposits of large size. Although the area has been thoroughly prospected, only a few tons of ore have been shipped from any of the openings and it is the belief of the writer that none of the deposits are of sufficient size or concentration to be workable under present conditions.

Grains and small masses of native copper have been found throughout the length of the large areas of greenstone in South Mountain south of the Gettysburg pike, shown on the map in Plate I. Numerous prospect tunnels, shafts, and open cuts have been opened at the most promising places, and copper "float" has been found over the surface at many places between these prospects. Extensive development has been carried on at several of the mines, and a reduction furnace to smelt the ore was constructed some years ago at one of them. The Virgin Copper Co. actively developed its properties in 1909, and a stock company had been organized to operate it. The Eagle Metallic Copper Co. was also developing its mine by a slope 450 feet long. Both mines have since closed down and are abandoned.

The copper was probably originally disseminated as copper sulphide in the lava and was concentrated and reduced to native copper in the process of metamorphism through which the rocks passed during the mountain-making movement in late pre-Cambrian time. While deeply buried within the earth these old rocks were intensely compressed and heated during the disturbance and were greatly altered

in form and composition. The amygdules and smaller vesicles in the porous lava became filled with minerals which had been dissolved from the rock by heated waters or had been formed by the metamorphic processes. Quartz and epidote were the chief minerals thus deposited, and some calcite, chlorite, and zeolites were formed. Copper sulphide disseminated in the rock was dissolved by the circulating water, probably as sulphate, and was redeposited together with the other minerals in the open vesicles and other favorable places by the reduction of temperature of the solution as it neared the surface or by reaction with other solutions or minerals. The copper was deposited in the native state due to the presence of a strong reducing agent, probably ferrous iron which became ferric in the formation of the epidote that was being deposited at the same time.

Descriptions of mines and prospects[1]:— The most active property in 1909 was the Virgin Copper Co.'s mine near the crest of a small hill 1 mile northwest of Gladhill station on the Western Maryland Railroad. When visited, it was opened by a 6 by 8 foot incline 215 feet long, sloping eastward at an angle of 47°. The incline started on a mineralized brecciated zone at the contact of sheeted greenstone and overlying more massive quartz-epidote rock, and had reached a depth of about 180 feet from the surface. Native copper occurs in the rock sparingly at the surface, and at a depth of 125 feet on the incline fine wires of copper impregnate the greenstone schist for a width of 2 feet. The mineralized zone is reported to have been prospected to the eastward by two drill holes, one 308 feet deep and the other 600 feet deep. At the 308-foot depth the mineralized zone was said to have been 7 feet thick and rich in copper, and it was planned to run a drift from the incline when this depth was reached. At a depth of 125 feet on the incline a test drift was run 10 feet west into the foot wall, which was composed largely of quartz and epidote with some calcite and chlorite. Considerable bright native copper in fine wires was found at the contact of the hard epidotic rock and sheeted greenstone, and the greenstone was more or less impregnated with copper for about 2 feet above the contact. The mine was equipped with head frame, iron skip cars, surface dump cars, 8-horsepower hoist, pump, 22-horsepower gasoline air compressor and tanks for compressed-air hand drills.

The Eagle Metallic Copper Co. was also operating in 1909. This mine is one-half mile southeast of Charmian, near Miney Branch. The Company was incorporated in New Jersey and its president and manager was H. G. Deshler, of Belvidere, N. J. The mine consisted of an incline 450 feet long, which descends southward at an angle of

[1]More detailed descriptions of the prospects and discussion of the origin of the ore are given in U. S. Geol. Survey Bu'l. 430, pp. 122-131, 1910, and in the biennial report of the Topographic and Geologic Survey commiss'on of Pennsylvan'a, pp. 57-69, 1914.

35°. It was equipped with tram cars, 20-horsepower hoist, blower, pump, drills, and assay house. The incline follows the contact of a massive greenstone just below and a zone of sheared and decomposed greenstone. The rock is copper stained and contains vein quartz, chlorite, epidote, and specks of hematite, but no native copper was seen. Chalcocite was reported to have been found at a depth of 100 feet and bornite and other copper sulphides at greater depth, but these claims were not verified and are probably not to be depended on. The old Headlight mine and other small prospect pits also occur in the valley of Miney Branch, east of Charmian.

One mile northeast of Gladhill station is the old Bingham mine, where a reduction furnace was operated many years ago. The property was later controlled by the National Copper Co., of Belvidere, N. J. The mine was opened by a cut 40 feet long into the hill and 20 feet deep at the face and had a pit 10 feet deep in the bottom. It is in sheared metarhyolite at its contact with greenstone, epidote-quartz rock forming the western foot wall and altered rhyolite the hanging wall. Scattered small grains of native copper surrounded by copper oxide occur in the altered rhyolite and the greenstone, and some of the joint surfaces of the metarhyolite are brilliantly stained by green and blue copper carbonates. The deposit exposed has no commercial value for its copper content, although an old shaft 40 feet deep is reported to have struck ore that assayed 4 per cent copper. The brilliantly colored altered rock, however may prove of value as an ornamental stone, as described on page 18.

The Reed Hill property, which is one-half mile farther north in the greenstone belt, was developed by the Reed Hill Copper Co. The chief workings are an open cut 100 feet long trending north and following the mineralized zone, from which run two tunnels in the same direction, each about 30 feet long. Several small prospecting pits are also scattered over the property. The rock is a massive dense epidote with quartz and chlorite. A little native copper was seen in the rock and in the material on the dump, but masses weighing as much as a pound are reported to have been found here.

The Russell property, 1 mile south of Mt. Hope, is on a small creek known as Copper Run. It was also developed by the Reed Hill Copper Co. A modern two-compartment shaft had been sunk to a depth of 145 feet and at a depth of about 115 feet a tunnel had been run eastward. When seen in 1909 it was equipped with an air compressor and a well-housed engine, all in good condition, but the mine was not open for inspection. It has since been abandoned. A mineralized zone 8 feet thick was reported to have been struck. The rock on the dump is epidote and quartz with some calcite, red jasper, and chlorite, and a little native copper.

High on the hill half a mile northeast of Mt. Hope the Snively, or old Musselman Hill, property was prospected by two shafts, each

50 feet deep, and by a tunnel. The copper-bearing rock is an amygdaloidal greenstone impregnated with native copper and is reported to be 8 feet thick, the same as it is said to be at the Russell property, and to lie between walls of chlorite schist. Large masses of copper "float" were also said to have been found here, one of which was reported to have weighed 27 pounds, but little credence can be given to such reports. The Deshler shaft on Culp Hill, just south of Middle Creek, was reported to have struck good ore, probably similar to that at the Snively mine.

On the Bingham farm, on the hill west of Mt. Pleasant school $1\frac{3}{4}$ miles north of Mt. Hope, native copper "float" is reported to have been found, and on the Baker farm, a mile farther north, copper-bearing rock was also reported.

At the head of Hayes Creek on the north slope of Snowy Mountain, 1 mile west of the county line, and 1 mile northeast of South Mountain Sanatorium, several small pits on the Kauffman and Wagaman farms expose dense greenstone in which there are small particles of native copper surrounded by a zone of cuprite. Other small pits and shafts in the greenstone east of Jacks Mountain, near the south boundary of the county, have small showings of native copper and specular hematite in epidote and quartz.

The quantity of copper seen in these extensive prospects is so small that notwithstanding the reports that large masses of native copper "float" have been found and that chalcocite occurs in depth, the deposits are regarded by the writer as of no present commercial value, and further prospecting, developing, or promoting is to be discouraged.

Copper in Triassic rocks.

Copper carbonate stains are numerous in the Triassic sediments of Adams County and have caused considerable speculation as to possible copper deposits of value in the region. The fact that commercial deposits of copper ore do occur in Triassic rocks at the old Schuyler mine near Arlington, New Jersey, lends some hope that such deposits may be found in this area, but the openings thus far made give no support to such hope. The ores in the New Jersey mine are chiefly copper sulphide with carbonates near the surface. They occur in brecciated sandstone adjacent to dikes and narrow intrusive masses of diabase and were deposited by heated mineralized waters that emanated from the intrusive magma.

Prospecting has been attempted at several places in the county. The greatest development was made half a mile north of Hunterstown, where the shale has been altered by a large intrusive mass of diabase to a brecciated slate with epidote veining and pink discoloration probably due to alteration of the iron oxide in the rock.

A little copper carbonate and iron oxide have stained the rock green and rusty but no copper ore was seen on the dump. An incline descends 200 feet westward at an angle of 60° and at the time of visit the prospect was equipped with hoist, crusher, and other machinery. The incline however was not open to inspection.

A smaller prospect 3 miles north of Hunterstown was opened in shale and sandstone altered by the diabase intrusion southwest of Plainview. Here the altered rock is discolored by copper carbonate but no copper ore was seen. Another small pit 1 mile east of Fairfield, is in shale altered by a large intrusive mass of diabase, but only small copper carbonate stains and a little sprinkling of hematite were seen. Copper carbonate stains may be seen on the Triassic sandstone in the roadway east of Rock Creek, 1 mile from Gettysburg, and at several other places about the city. None of these however are favorable indications of commercial ore deposits.

IRON.

Brown ores.

Brown iron ore (chiefly limonite, a hydrous oxide of iron) occurs principally along the western base of but also within the South Mountains along the border of limestone areas. Similar deposits occur also at the foot of the Pigeon Hills in the eastern part of the county and at the northwest foot of the slate hills in the southeast corner. Some of these deposits are large and of high grade and have been extensively mined. The larger known deposits, most of which were outside of Adams County, have been mined out to the limit of depth of profitable working under present conditions. The low price of this kind of ore at the present time limits its production to readily accessible, easily mined deposits.

The brown ores in South Mountain occur mostly in the wash and residual clay that cover the limestone at the foot of the steep mountain slopes. The iron is believed to have been leached chiefly from the basal beds of limestone or dolomite and the uppermost calcareous quartzites as they weathered on an old peneplained surface. The solutions penetrated the mantle of residual sand and gravel and the iron was redeposited as oxide at its base, partly cementing the sand and gravel and partly replacing it. This ore belt enters Adams County only in 3 areas of small extent—in several narrow valleys at the head of Conococheague Creek; in Mountain Creek Valley; and at Maria Furnace north of Jacks Mountain, 2 miles southwest of Fairfield.

In the valley of Conococheague Creek, Franklin County, just west of Caledonia Park which is on the site of the old Caledonia furnace, there are several old ore pits and tunnels at the contact of the Cambrian limestone and quartzite from which iron ore was ob-

tained for the old furnace. This ore is described in the old reports as mountain ore and much of it was highly siliceous. Ore pits also occur in similar geologic relations at the forks of Hosack Run, 1½ miles north of Caledonia Park, just west of the Adams County line. At the east foot of Wolf Hill, Adams County, 3½ miles northeast of Caledonia Park, similar siliceous mountain ore was taken out of an old tunnel and other iron ore pits. These are at or near the contact of the Cambrian quartzite and overlying limestone, in a sharp syncline between the line of foothills of which Wolf Hill is one and the outlying Yellow Ridge line of hills. The Wild Cat ore banks are located near the head of Mountain Creek Valley, in Cumberland County just north of the Adams County line. They were worked in conjunction with the ore banks at Pine Grove, a few miles farther northeast down the Mountain Creek Valley, and furnished ore for the old Pine Grove furnace. This deposit is also near the contact of the Cambrian limestone and quartzite, but the deposition of ore may have been in part influenced by the circulation of water along a fault which passes close by. A large hole filled with water in the lowland at Maria Furnace is an old iron ore pit located on a small area of limestone adjacent to the Cambrian quartzite in a small fault block. The quantity of ore extracted from most of these pits was relatively small compared with that from the extensive workings at the west foot of South Mountain in Franklin County, particularly in the vicinity of Montalto and Cleversburg, and at Pine Grove Furnace in Cumberland County.

Brown iron ores similarly occur in the sandstone wash that overlies the limestone of the valley on the south flank of the Pigeon Hills. The uppermost beds of the Cambrian quartzite are here highly ferruginous and on weathering give rise to a deep red ferruginous soil in which iron ore deposits occur at many places. Only one small ore pit of this group occurs within the county—McConaughy's ore bank, 2½ miles east of New Oxford. Several of the old large ore banks lie east of the county line, the nearest one being the old Ashland mine, 3 miles distant.

Brown iron ores have been extensively mined at the foot of the slate hills in the southeast corner of the county. They lie chiefly in the decomposed slate at or close to the fault contact of the slate and limestone and were apparently deposited by waters that had dissolved the iron from pyrite and other iron-bearing minerals in the schist or slate and redeposited it as oxide on reaching the surface along the fault plane. The location of the mines, which were operated chiefly prior to 1874, is shown on the geologic map, Plate I. None of the pits expose the bedrock, and geologic relations therefore can not be observed. Eight ore pits are reported[1] to occur

[1]Persifor Frazer, Jr., 2nd Geol. Survey of Pa., Rept. C, 1874, pp 42-46.

in this part of the county. They will be described beginning at the east, near Mt. Pleasant.

The Samuel Schwartz bank, $\frac{1}{4}$ mile southwest of Mt. Pleasant, is marked by a large deep hole. More than 1,000 tons of ore were removed before the ore ran out. The ore was shipped to the Henry Clay furnace. The ore is at the fault contact and lies in parallel layers in crystalline schist, supposed to follow the bedding, which dips 45° SE.

Solomon Schwartz bank is $\frac{3}{4}$ mile southwest of Mt. Pleasant. Two large holes on opposite sides of the Hanover-Littlestown road, each about 40 feet deep, mark the old workings where over 2,000 tons of ore were removed. Large quantities of ore were reported exposed in the clay walls when operations ceased.

David Boyer bank is near the Pennsylvania Railroad, (Frederick Branch) east of Sells station. This pit is a large shallow hole partly filled with water. It lies in the limestone area, below the fault, and its banks are of clay. It was worked for two years by Lancaster men.

The Lefevre pits, which are above the Hanover-Littlestown road in the shale area above the fault, consist of several small shallow openings and a 20-foot shaft. Little ore was taken out.

The Krumrein pits also are within the shale area on the hill slope south of the turnpike. Only 40 tons of ore are reported to have been shipped.

The Early and Killinger mine, the largest bank in this group, is about 1 mile east of Lefevre station on the Pennsylvania Railroad. A large deep hole south of the turnpike marks its location. The ore was in layers in disintegrated clay-shale which dipped southeast about 15°. Limestone and iron ore cropped just below the mine, so it marks the fault contact. The analysis of the ore by McCreath shows the following components:—

Analysis of brown ore.

Iron	46.9
Manganese	.8
Sulphur	.1
Phosphorus	1.2
Silica	12.3
Alumina	1.0

The Enoch Lefevre bank is $\frac{1}{4}$ mile southeast of Lefevre station, south of the turnpike. It is a trench 1,200 feet long in a northeast direction. Various operators took out a large quantity of ore during a 20-year period, and lump ore was reported in the bank when abandoned.

The Widow Clark bank is about $\frac{1}{4}$ mile south of the turnpike at the Lefevre railroad crossing. Two large banks about 1,000 feet

apart have been worked, and the deeper one had an inclined tunnel entry. A large amount of ore was removed.

Although some workable deposits of brown iron ore may still occur in the county, they are so scattered and so deeply buried that they can not be economically worked at the present low price of this grade of ore. Not until the great deposits of more easily minable high-grade ores in other parts of the world are exhausted will the local deposits of brown ores again become of value.

Specular hematite.

Although attractive pieces of this mineral have been found at many places in the area, the quantity present is apparently so small that there is no probability of its occurrence in minable quantity.

Specular hematite occurs with the quartz in many of the quartz veins in the pre-Cambrian volcanic rocks of South Mountain. The large quartz vein at the head of Buchanan Valley contains so much hematite that it has been prospected at Cole's ore bank, 2 miles north of Newman school. Chunks of solid specular hematite the size of one's fist are found, but most of the pieces are small and the quantity present is not sufficient to be of commercial value. Good specimens of hematite occur in the quartz vein on the hill 1 mile west of Cashtown, and smaller pieces are present at the contact of greenstone and metarhyolite west of Virginia Mills and north of Marshall.

Small quantities of hematite are found in the copper-bearing greenstone between Gladhill and Mt. Hope, on Hayes Creek, and east of Jacks Mountain, but the amount is very small and it is of no value. A little hematite also occurs in the copper-stained Triassic rocks in the prospect pit 1 mile east of Fairfield.

At the west base of the Pigeon Hills a mixture of massive specular hematite and red jasper occurs at the contact of Cambrian quartzite and limestone. This is a fault contact and the ore is apparently a partly replaced fault breccia. The large quantity of float ore and its high character make this deposit appear to be the most promising of its kind in the county. It has not been prospected, so its extent can not be determined.

Magnetite.

General occurrence.—Several deposits of magnetite have been mined in Adams County, none of which are at present being worked. Geologic relations in parts of the county are so similar to those near Dillsburg, Cumberland County, and Cornwall, Lebanon County, where extensive deposits of magnetite are associated with Triassic rocks, that it is believed workable deposits of commercial value may yet be found in Adams County. Some areas which show no evidence of ore deposits at the surface but which have underground

conditions that appear to be favorable for ore deposition are therefore herein described as favorable ground for prospecting with a drill with possible hope of discovering commercial deposits in depth.

Scattered magnetite crystals also occur in the metamorphosed Cambrian sediments and in the pre-Cambrian volcanics, and in one place are so concentrated that the rock has been prospected for iron.

Description of mines and prospects.—The largest deposits that have been mined in the county lie at the south foot of Fox Hill, a diabase hill about a mile east of Cashtown. (See Plate I.) These deposits were worked many years ago and good magnetite "float" is still scattered over the fields. The old workings are inaccessible, and the details of the following description of the deposits are largely from the Pennsylvania Second Survey report[1].

Two mines were operated here about 50 years ago. The Adam Minter mine, on the west, was opened by an incline 132 feet long with several drifts leading from it, the longest being 179 feet. The ore bed was reported to be variable but at the lowest level it was apparently 2 to 2½ feet thick. The country rock is a fine calcareous conglomerate in the Triassic sandstone. The ore is said to have analyzed 46 to 46.9 per cent iron. It is stated that over 2,500 tons of ore were extracted.

The Peter Comfort mine on the J. P. Butt farm just east of the Minter mine was opened by several slopes that followed separate ore bodies down the bedding of the rock, from which drifts were run into the ore. The longest incline reached a depth of 125 feet. One ore bed is reported to have been 2 feet thick. In addition numerous small surface pits and shallow slopes were scattered over the surface for several acres. The amount of ore taken out is believed to have been about equal to that from the Minter mine.

Good ore was also found on farms about Center Mills, and one property there was opened to a depth below water level on an ore bed reported to be 15 to 24 inches thick. According to analysis by F. A. Genth of the Pennsylvania Second Geological Survey, it ran 67.97 per cent iron.

Several deposits in the vicinity of Idaville were also worked. The Widow Bruch's bank, 1½ miles southeast of Idaville, was opened about 1835 and was worked for 20 years. The pit was dug 50 feet deep and a drift driven from its bottom. Ore was taken out by hand windlass and sent to Chestnut Grove furnace at Idaville, then called Whitestown. Mining was stopped because of water. Much float magnetite was reported on the Peter Dalhammer property, adjoining the Bruch tract on the south, and a prospect shaft was said to have revealed large masses of ore. No mining was done.

[1]Frazer, Persifor J., Pennsylvania Second Geol. Survey Rept. C 2, pp. 242-244, 250-253, 1875.

The Albert ore bank, 1 mile southeast of Idaville, was opened about 1830, and was operated for 20 years. Ore was removed by cart and at first was sent to the furnace at Carlisle by wagon, but later it was hauled to Hunters Run station and shipped to Carlisle by rail. The ore was magnetic and occurred in nests or pockets, of about 1,000 tons each. Ore was also mined on adjacent property for the Chestnut Grove furnace.

Several small openings were reported on the McNair and adjacent farms southeast of Fairfield, in the southern part of the county. Several prospecting pits were dug and a 90-foot incline sunk, but not enough ore was encountered to encourage mining. Ore has been reported at several places near the intrusive diabase southeast of Orrtanna, especially on the east side of Carr Hill. Ore was also reported struck in a well at Orrtanna, close to the diabase contact. These prospects are indicated on the map, Plate I.

One mile north of Gargol, a mineralized crushed zone in the metarhyolite which has been prospected for iron, contains large numbers of magnetite crystals in quartz. The quantity of magnetite is insufficient to be an ore but attractive octahedral crystals of magnetite are obtainable.

Origin of the ore.—Various theories of the origin of this type of deposit have been advanced, but the generally accepted conclusion of present day writers is that the magnetite is a metasomatic replacement of calcareous sedimentary rocks by hot mineralized solutions set into circulation by the intrusion of diabase.[1] With this conclusion the author is entirely in accord. The solutions are believed to have emanated from the intruding mass, and to have been so hot that they had many of the qualities of vapor, although probably kept in the liquid form by the high pressure within the rocks. The theory that the ore deposits had been formed in the sediments before the intrusion of the diabase but that their condition may have been altered by the intrusion seems to have been generally held previous to Spencer's paper.[2]

Magnetite is a conspicuous component of much of the diabase which is intrusive in the Triassic sediments. Black streaks in the soil of the diabase hills are composed of magnetite derived from the disintegration of the diabase and concentrated by rain water. Some of the diabase masses are more heavily charged with crystals of magnetite than are others, the diabase of Chestnut Hill southeast

[1]Spencer, A. C., Magnetite deposits of the Cornwall type in Pennsylvania: U. S. Geol. Surv. Bull. 359, p.13,1908.

[2]Rogers, H. D., Geology of Pennsylvania, vol. 2, pp. 687, 708, 718, 1858. Hunt, T. S., The Cornwall iron mine and some related deposits in Pennsylvania: Trans. Am. Inst. Min. Eng., vol. 4, pp. 508-510, 1875.

Frazer, P., jr., Pennsylvania Second Geol. Survey, Rept. CC, pp. 198-400 1877. Also, a study of the specular and magnetic iron ores of the new red sandstone in York County, Pa.: Trans. Am. Inst. Min. Eng., vol. 5, pp. 132-143. 1877.

Lesley, J. P., and D'Invilliers, E. V., Report on the Cornwall iron-ore mines, Lebanon County: Ann. Report, Pennsylvania Second Geol. Survey, for 1885, 1886, pp. 491-570; Final Rept. Pennsylvania Second Geol. Survey, vol. 1, pp. 351-357, 1892.

D'Invilliers, E. V., The Cornwall iron-ore mines, Lebanon County, Pa.; Trans. Am. Inst. Min. Eng., vol. 14, pp. 873-904, 1886.

of Bendersville being most conspicuously so, but none of the rock has sufficient iron to be classed as ore.

The known deposits of magnetite in Adams County are in the Triassic sedimentary rocks immediately adjacent to diabase intrusions, and were evidently formed in the process of metamorphism of the sedimentary rock. In the Cornwall mine at Cornwall, Lebanon County, the ore is largely a replacement of Paleozoic limestone at the contact of the intrusive diabase, whereas in the mines around Dillsburg the ore is chiefly a replacement of the basal Triassic calcareous breccia containing limestone pebbles at its contact with diabase intrusives. Details of the occurrence and relations of the ore at those places and a discussion of the origin of the ore are given by A. C. Spencer in his report.[1]

The ores in the Minter and Comfort mines in Adams County are similar replacements of calcareous Triassic sandstones. The wall rock is described in the reports as a fine calcareous conglomerate, but in the rock fragments on the old dump magnetite and other metamorphic minerals, chiefly garnet, do not seem to replace limestone pebbles but appear to be altered zones and nodules in the sandstone. Evidently these zones and lumps were originally calcareous, which favored their replacement by or alteration to the metamorphic minerals. The iron was evidently deposited by hot iron-laden solutions which accompanied or emanated from the intruding molten diabase and circulated in the adjacent sedimentary rocks, dissolving the calcareous layers and limestone nodules or pebbles and replacing them with magnetite. Some of the calcareous sand of the rock was at the same time altered to garnet.

The fact that magnetite is so large a primary constituent of much of the diabase is evidence that this mineral formed a prominent part of the molten magma from which the diabase came, and that this magma was the source of the iron in the hot solutions. The more direct the connection between a diabase mass and the source of the molten magma, the greater will be the heat of these solutions and their quantity and therefore the greater will be the metamorphic effect on the invaded rocks. The writer believes that the diabase in this area came into the Triassic rocks chiefly through a longitudinal vent following a fault in the underlying Paleozoic rocks near the western border of the Triassic sedimentary rocks. From this stocklike dike an offshoot between the beds formed the thick sill whose outcrop crosses the county diagonally northwestward, just east of Gettysburg. (See Pl. I.) The greatest alteration of the rocks, therefore, should be expected adjacent to diabase masses which lie near the locus of the intrusion, and the greatest metasomatic replacement and the largest deposits of magnetite may be expected

[1] Op. cit.

where these masses cut limestone or calcareous strata. That would be at the base of the western part of the Triassic sandstone and in the underlying Paleozoic limestone. (See cross sections, fig. 1.)

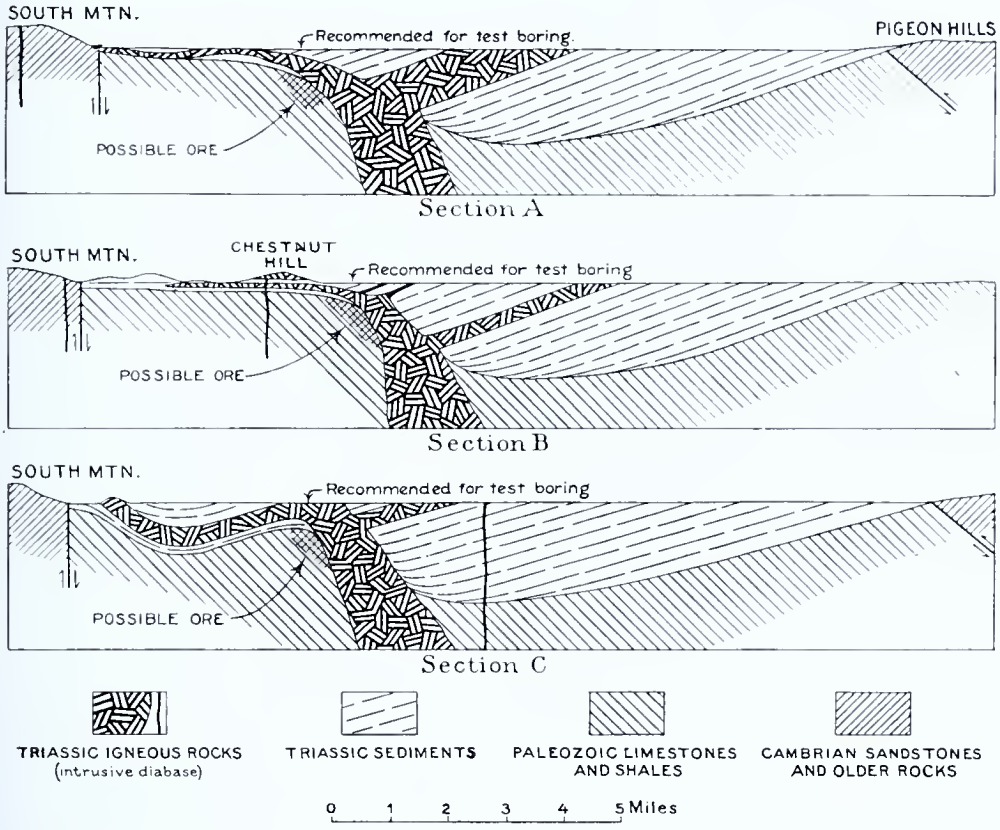


Figure 1. Structure sections across the Triassic rocks in Adams County, showing probable relation of magnetite deposits to the intrusive diabase.

Areas favorable for prospecting.—The most favorable conditions as above postulated occur near the western margin of the Triassic sedimentary rocks, particularly east and north of Fairfield and in the northern part of the county east of Bendersville. The surface has apparently been thoroughly searched for indications of ore, and small deposits have been prospected and worked, but none of large size have been found. Workable deposits may still be hoped for, however, below the surface, where the contact of the intruded diabase and calcareous beds is hidden by Triassic sediments. The high grade of the magnetic ore warrants further search by the use of the drill in favorable localities. It is therefore recommended by the writer that certain most favorable tracts, indicated on the map in Plate I and described below, be so prospected. These tracts are as follows:—the area adjacent to the diabase sills or elongated intrusive masses north of Center Mills and Heidlersburg and extending to Gargol and

York Springs; that around the large crosscutting diabase body south of Orrtanna; that close to the diabase sill on which Knoxlyn is located. If workable bodies of ore occur at these places they probably lie at or near the base of the Triassic sedimentary beds, 100 to 500 feet or even more beneath the surface, and can possibly be detected by the use of the dip needle, but more certainly by systematic drilling.

MANGANESE MINERALS.

Manganese minerals are associated with the brown iron ores at many places along the west foot of South Mountain, and are found in considerable quantity near Mt. Holly Springs, Cumberland County, a few miles north of the Adams County boundary. No manganese deposits have been found in Adams County under similar geologic relations, and it is probable that manganese ore does not occur there in commercial quantity. Some manganese oxide occurs with the brown iron ore in the slate hills in the southeastern part of the county, but not in sufficient quantity to be mined separately from the iron ore.

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